FEMA-296, 10/92

Code Compatibility Report

Federal Insurance Administration
Federal Emergency Management Agency

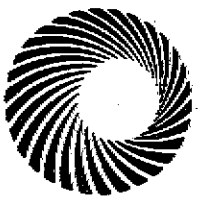
10/92
Volume 1 of 3

Code Compatibility Report

Sponsored by

The Federal Emergency Management Agency

October, 1992



National Institute of
BUILDING SCIENCES
1201 L Street, N.W., Suite 400
Washington, D.C. 20005

PREFACE

In August of 1991 Hurricane Bob inflicted extensive flood damage along the coastlines of Rhode Island and southern Massachusetts, contributing to the destruction of or substantial damage to 75 to 90 percent of the homes on barrier beaches. Later in October of the same year a nor'easter battered the Atlantic coastline with unexpectedly destructive flooding. Widespread flooding occurred in Texas when rivers overflowed their banks from heavy rains brought on by the "El Nino" warming in Pacific waters, *a phenomenon* which recurs every three to five years.

These three events in a single year underscore that construction of buildings to reduce hazards in flood-prone regions of the United States is an essential part of the national strategy to minimize the impact of natural disasters. Commercial, industrial and residential structures that have been constructed to adequately resist flood hazards according to technical guidelines and standards of the National Flood Insurance Program (NFIP) have fared best in floods.

The Federal Emergency Management Agency (FEMA), which prepares and distributes the NFIP technical guidelines and standards for reduction of flood hazards, has recognized that flood hazard reduction standards can be more widely implemented in flood-prone communities by their incorporation into the model building codes and standards which are adopted by the states and enforced on a regular basis by local building *departments.*

This study represents a major step toward eliminating the incompatibilities between the NFIP technical guidelines and standards and the model codes and standards. The report's recommendations provide a basis for coordinating NFIP documents with model codes and standards. In addition the report represents a starting point for the preparation of standard design guidelines, and eventually, a consensus standard for flood-resistant construction which can be referenced in the model building codes.

The National Institute of Building Sciences appreciates the opportunity to assist the Federal Emergency Management Agency in improving the levels of compatability between the NFIP guidelines and technical standards and the model building codes and standards. The Institute wishes to thank the members of the Flood Standards Project Committee for their insights and efforts in developing this document, especially G. Day Ding, the project committee chairman and Earl Flanagan, the vice-chairman. The Institute also wishes to commend the efforts of the subcontractors, the Building Officials and Code Administrators, International (BOCA), the Southern Building Code Congress International (SBCCI), the International Conference of Building Officials (ICBO), the National Fire Protection Association (NFPA), and the National Conference of States on Building Codes and Standards (NCSBCS), which contributed to report drafts for the project committee's review. The project committee members and subcontractors are listed in the appendix of the report.

The Institute accepts the recommendations of the Flood Standards Project Committee and approves their dissemination to the Federal Emergency Management Agency for implementation and to the public.

Robert C. Gibson, P.E.
Chairman of the Board

David A. Harris, AIA
President

TABLE OF CONTENTS

ABSTRACT

This study evaluates the compatibility of flood loss reduction standards of the National Flood Insurance Program (NFIP) with the construction standards for seismic, fire, and wind hazards that now appear in nationally recognized model building codes and standards and identifies those that are in conflict. Changes to the NFIP standards and technical guidelines and code change language for model codes and standards are recommended to resolve identified incompatibilities.

Keywords: codes, floods, guidelines, regulations, standards

INTRODUCTION

The purpose of this study is to evaluate the compatibility of flood loss reduction standards of the National Flood Insurance Program (NFIP) with the construction standards for earthquake, fire, and wind hazards that now appear in the nation's model building codes and standards, and identify any that are in potential conflict and recommend possible solutions.

This study was performed by a project committee of volunteers from the public and private sectors of the building community, operating in accordance with NIBS' consensus procedures. The final report was prepared according to NIBS guidelines for preparing reports. During the course of the project the committee oversaw the preparation of comparisons between the NFIP flood resistant design standards in 44 CFR 59 and 60, and sixteen related technical guidance documents and twenty-three model code and standard documents. Based on these comparisons incompatibilities were identified and recommendations written to address those incompatibilities. The project committee was supported in its work by five model codes and standards organizations: the Building Officials and Code Administrators, International (BOCA), the Southern Building Code Congress International (SBCCI), the International Conference of Building Officials (ICBO), the National Fire Protection Association (NFPA), and the National Conference of States on Building Codes and Standards (NCSBCS). A list of project participants is provided in Appendix 1 of the report.

Chapter 1 of this report provides background on the NFIP flood program, and the FEMA documents and the model codes and standards utilized in the study. A description of previous and future FEMA efforts for promoting compatibility between the FEMA documents and the model codes and standards is also provided.

Chapter 2 lists 23 model code/standards and 22 FEMA/NFIP publications reviewed for this study. Although this chapter lists 22 NFIP documents, one of the technical guidance documents (FEMA-15) and two of the technical bulletins (86-1 and 90-1) were not used in the comparisons for reasons cited in Appendix 1. Interpretative correspondence was reviewed only to clarify aspects of NFIP documents in the project. The model codes and standards are organized under six major code group headings: the BOCA National Codes, the Standard Codes, the Uniform Codes, the NFPA Standards, the Manufactured Housing Codes and Standards, and the CABO 1 & 2 Family Dwelling Code.

In Chapter 3 of the report is an overview summary of the major issues underlying incompatibilities identified in the evaluation of FEMA documents and the model codes and standards. This evaluation consists of comparisons of Federal Emergency Management Agency (FEMA) documents with the BOCA National codes, the Standard codes, the Uniform codes, the NFPA standards, the manufactured housing codes and standards, and the CABO 1 & 2 Family Dwelling Code. These comparisons are found in Appendices A through F of this report. Issues in the chapter are categorized by the code groups described above. For each comparison issues concerning the model codes and standards are listed first followed by issues for the FEMA documents.

Chapter 4 contains the recommendations for changes to NFIP standards and technical guidelines. The chapter is organized into six sections, 4A through 4F, by the same major groups of model codes and standards found in Chapters 2 and 3. Recommendations in each section are organized by the model codes and standards as listed in Chapter 2 under each major code heading. The name of the particular code or standard on which each recommendation is based (even if the issue in the recommendation is not directly

addressed in the document), is found on the right-hand side of the page above the text describing the recommendation. The corresponding NFIP documents which were compared with the model code or standard in the development of the recommendation are listed on the left-hand side of the page. Below each recommendation is a reference to the page and paragraph in the comparisons found in Appendices A through F.

Chapter 5 contains code change language for resolving incompatibilities between the NFIP standards and technical guidelines and the model codes and standards. Like Chapter 4, this chapter is also organized into six sections, 5A through 5F, by the same groups of major model codes and standards found in Chapters 2 and 3. Recommendations in each section, however, are organized by the NFIP documents as listed in Chapter 2. The name of the particular NFIP document on which each code language change is based, is found on the left-hand column on the page above the text describing the code change. Passages in the model code or standard which are affected by the code change are listed in the center column. The analysis supporting the code change is in the right-hand column. Each code change entry, including the referenced documents, the analysis and code change text has been taken verbatim from the comparisons in Appendices A through F.

Appendix 1 lists the project committee members and consultants who participated in the study. Appendix 2 is a glossary of acronyms found throughout the report.

Appendix 3 is a general description of each FEMA and NFIP publication as they relate to the overall codes and standards development process. The considerable data in the publications concerning the NFIP program, site considerations, classification of flood zones and other areas have not been included in the summaries. Instead, only the material utilized in the comparisons is briefly cited in the NFIP document summaries.

Appendix 4 is a general description of the content of each model code/standard publication.

Appendix A contains the comparison between the family of BOCA Codes and the NFIP standards and technical guidelines.

Appendix B contains the comparison between the family of Standard Codes and the NFIP standards and technical guidelines.

Appendix C contains the comparison between the family of Uniform Codes and the NFIP standards and technical guidelines.

Appendix D contains the comparison between the NFPA standards and the NFIP standards and technical guidelines.

Appendix E contains the comparison between the manufactured housing codes and standards and the NFIP standards and technical guidelines.

Appendix F contains the comparison between the CABO 1 & 2 Family Dwelling Code and the NFIP standards and technical guidelines.

CHAPTER 1

BACKGROUND

NFIP Standards and Technical Guidelines

The National Flood Insurance Program (NFIP) was created by Congress in 1968 to provide federally backed flood insurance coverage since it was generally unavailable from private insurance companies. The NFIP was also intended to reduce future flood losses by ensuring that new development is adequately protected from flood damages. The NFIP is based on a mutual agreement with communities that have been identified as flood-prone. The Federal Emergency Management Agency (FEMA), which is the agency charged with administering the program, makes flood insurance available throughout a community provided that the community adopts and enforces adequate floodplain management regulations that meet the minimum requirements of the NFIP. This is accomplished through a local floodplain management ordinance which must either meet or exceed the minimum NFIP criteria. These minimum criteria are located in 44 CFR 60.3 and 60.6, and they establish design performance standards for buildings located in Special Flood Hazard Areas that specify how a structure should be constructed in order to reduce or eliminate the potential for flood damage.

To assist in the application of these requirements by the building community, which includes building code officials, local building officials, engineers, architects, builders, developers, and the general public, FEMA has developed technical guidance manuals and informational materials for public distribution. These materials contain guidelines that specify the use of certain techniques and materials for design and construction which will meet the intent of the NFIP general performance criteria for flood damage resistant construction. These publications report what is considered to be standard practice for flood resistant design and construction techniques.

The NFIP technical guidance documents have been written within the previous fifteen years either inhouse or under FEMA contract with various architects, engineers, and private organizations. As a result, the NFIP documents vary in approach and level of technical detail. For example, it appears that the Coastal Construction Manual which emphasizes wood superstructure was written from an architect's point of view. Floodproofing Non-Residential Structures which emphasizes foundation systems appears to have been written from the vantage point of an engineer. In terms of technical detail different levels of information are related for the same construction types. For example, some publications give rules of thumb while others offer structural tables. Finally, referencing between documents tends to be broad in scope and duplicates information. Chapter 2 lists 22 NFIP documents reviewed in the study, however, three were not used in the comparisons for reasons cited in Chapter 3.

Model Codes and Standards

The model codes and standards have been developed by consensus over a period of years under the auspices of the organizations (i.e. CABO, BOCA, SBCCI, ICBO, NFPA and ANSI) which promulgate the written documents.

The three national model codes are: BOCA National Building Code, which is a product of the Building Officials and Code Administrators (BOCA), and is generally adopted by eastern and mid-western States; Standard Building Code, which is a product of the Southern Building Code Congress International (SBCCI), and is generally adopted by southern States, and; Uniform Building Code, which is a product of the International Council of Building Officials (ICBO), and is generally adopted by western States.

In addition, there is a fourth model building code known as the CABO (Council of American Building Officials) One and Two Family Dwelling Code. This model code is used in various parts of the country for residential structures.

The National Fire Protection Association (NFPA) Life Safety Code is adopted in many areas of the country. The NFPA National Electrical Code is a national standard referenced by each of the three model codes.

These documents follow standardized formats for content and references, and within the families of codes (i.e. National, Standard and Uniform) the documents reference one another without duplicating information. For example, information on mechanical systems is found in exclusively the Standard Mechanical Code. The Standard Building Code only addresses construction which comes in contact with mechanical systems.

The manufactured housing codes and standards have their origins in a Federal program. The HUD Handbook 4930.3 and the Manufactured Housing Construction Safety Standards (MHCSS), are promulgated by the Department of Housing and Urban Development. The third, the Manufactured Housing Installation Manual (MHIM), written by the Manufactured Housing Institute (MHI), is designed to reference 4930.3 and the MHCSS. These documents contrast in origin with model building codes and NFPA documents which are promulgated by consensus based organizations. Such organizations are part of the Board for the Coordination of the Model Codes (BCMC) process which has coordinated each of these codes in many areas in the last ten years.

The other documents in the manufactured housing code comparison, ANSI A225.1, Appendix C of the CABO 1 & 2 Family Dwelling Code, and NFPA 501A, are either part of the families of the model codes or in the ANSI standard's case is referenced by the model codes. A list of the model codes and standards referenced in this study is found in Chapter 2.

NFIP Standards and the Model Codes

FEMA has undertaken a multi-year effort to incorporate the NFIP flood damage resistant design standards into the nation's model building codes, which are then adopted by either States or local communities.

This effort involved the extraction of specific building criteria from the NFIP floodplain management requirements (44 CFR Parts 59 and 60) and revising the language into a code format. This language was then submitted to the model building code groups as a proposed code change. The code change process consists of a recommendation for approval or disapproval by a code change panel at an annual code change hearing, followed by a vote by eligible model code members at an annual conference. FEMA's approach to this process has involved either working directly with the code organization or closely coordinating with State and local officials to submit the code change proposals.

As of this date, two model building code groups have accepted and published extensive sections of the NFIP floodplain management regulations that pertain to building standards. A third has recently accepted flood related language.

The BOCA National Building Code has already adopted the majority of the NFIP building regulations into the main body of its Building Code, as well as in the BOCA Mechanical, Plumbing and Fire Prevention Codes. The Building Code language is presently located under Section 2101.6. The title of Article 21 is Exterior Walls with Section 2101 entitled Performance Requirements, Exterior Walls. There are several administrative and land use sections of the NFIP regulations that are not covered by the BOCA Code. Because this language is located in the main body of the Building Code, it is unlikely that they can all be included.

The Standard Building Code (SBCCI) is the only model building code that has adopted all of the NFIP regulations. This is the result of a series of code changes submitted in 1986 and 1988. This language is located in a separate standard, the Standard For Floodplain Management (1989 Edition), and is referenced in the Standard Building Code under Section 1209. The Standard for Floodplain Management has been reviewed by FEMA Regions IV and VI and they have accepted it as a satisfactory alternative to their model ordinances. This is possible because this language is located in a separate Standard, although as a separate, it must be purchased and adopted independently.

The Uniform Building Code (ICBO) recently added flood resistant design standards in an appendix chapter. The language is similar to that of the BOCA Code in that it only covers the construction related requirements of the NFIP. The code language was submitted by the ICBO's High Wind/Hurricane Committee, and was based on a 1988 code proposal that was submitted by the State of California, Department of Water Resources and FEMA.

The purpose for FEMA involvement with the model building codes is that with the NFIP design requirements in the building codes, they have become more accessible, more credible, and easier to use and enforce by the building community. The same kind of involvement has not yet occurred with the organizations promulgating the NFPA standards and the manufactured housing codes and standards.

Future Directions

The nation's floodplains continue to be the site of significant amounts of new construction as well as the rehabilitation of existing buildings. In order for the NFIP to accomplish its goal of reducing the nation's flood losses, FEMA must encourage building practices that minimize flood damage to buildings located in flood-prone areas. At the same time, FEMA must ensure that there will not be any negative impact from these flood resistant design standards on the model building codes and the standards that they use to protect structures from other types of natural and man-made hazards.

Future efforts by FEMA to work with the model code groups is evolving. FEMA will continue to work with individual model code groups to place as much of the NFIP floodplain management standards as possible into the model building codes. A possible future initiative is the development of a consensus standard through a nationally recognized standards organization. The advantages to this action are that a national consensus standard is more credible and the same code language would then exist nationwide. FEMA has proposed that the American Society of Civil Engineers form a Flood Damage Resistant Design Standards Committee. One of the purposes of the committee will be the development of design standard guidelines for flood resistant construction through a consensus process. This will be an initial step leading to the development of consensus standards. FEMA also intends to interact with the Department of Housing and Urban Development to coordinate HUD documents with flood resistant standards and technical guidelines.

CHAPTER 2

LIST OF STUDY CODES AND STANDARDS

The FEMA and NFIP flood resistant design standards and technical guidelines listed in this report include:

1. National Flood Insurance Program Regulations for Floodplain Management and Flood Hazard Identification
   (44 CFR 59.1, 60.3 and 60.6)
2. Coastal Construction Manual (FEMA-55)
3. Elevated Residential Structures (FEMA-54)
4. Retrofitting Flood Prone Residential Structures
   (FEMA-114)
5. Floodproofing Non-Residential Structures (FEMA-102)
6. Manufactured Home Installation in Flood Hazard Areas (FEMA-85)
7. Alluvial Fans: Hazards and Management (FEMA-165)
8. Design Guidelines for Flood Damage Reduction (FEMA-15)
9. Manual for the Construction of Residential Basements in Non-Coastal Flood Environs
10. Technical Standards Bulletins:
    - Wet Floodproofing, No. 85-1
    - Foundation Wall Openings, No. 85-2
    - Breakaway Walls, No. 85-3
    - Hurricane Damage Patterns: A Focus on Pile Foundations, No. 86-1
    - Wind Design Standards and the NFIP, No. 88-1
    - Flood Resistant Materials, No. 88-2
    - Free of Obstruction Requirement in Coastal High Hazard Areas, No. 88-3
    - Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4
    - NFIP Pile or Column Requirement in Coastal High Hazard Areas, No. 90-1
    - NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2
    - Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3
    - Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4
11. Interpretative correspondence.

Model codes and standards which contain provisions for seismic, fire, and wind hazards include:

National Codes (BOCA):

1. 1990 BOCA National Building Code
2. 1990 BOCA National Fire Prevention Code
3. 1990 BOCA National Mechanical Code
4. 1990 BOCA National Plumbing Code
5. 1990 BOCA Property Maintenance Code

Standard Codes (SBCCI):

6. 1991 Standard Building Code
7. 1989 Standard for Flood Plain Management
8. 1991 Standard Mechanical Code
9. 1991 Standard Gas Code
10. 1991 Standard Plumbing Code

Uniform Codes (ICBO):

11. 1991 Uniform Building Code
12. 1991 Uniform Mechanical Code
13. 1991 Uniform Plumbing Code

NFPA Standards:

14. NFPA 101 - 1991 Life Safety Code
15. NFPA 70 - 1990 National Electrical Code
16. NFPA 54 - 1988 National Fuel Gas Code
17. NFPA 58 - 1989 Standard for the Storage and Handling of Liquified Petroleum Gases

Manufactured Housing Codes and Standards:

18. ANSI A225.1-87, Manufactured Home Installations
19. HUD Manufactured Home Construction and Safety Standards, Part 3280 with interpretative bulletins
20. Permanent Foundations Guide for Manufactured Housing, 4930.3
21. Model Manufactured Home Installation Manual
22. NFPA 501A - 1987 Standard for Firesafety Criteria for Manufacture Home Installations, Sites and Communities

CABO 1 & 2 Family Dwelling Code:

23. 1989 CABO One and Two Family Dwelling Code with 1990/1991 amendments

CHAPTER 3

SUMMARY OF ISSUES

An Overview of Issues

From a survey of the comparisons of NFIP standards and technical guidelines with the seismic, wind and fire safety provisions in the model codes and standards, it is apparent that issues leading to recommendations for changes to each of the model codes and standards vary with each code, while issues for the NFIP documents cluster into several recognizable themes.

In the comparison between the FEMA documents and the BOCA National Building Code, BOCA raised issues for its code that concern the means and methods of construction. Issues identified by SBCCI for the Standard Building Code reflect concerns with mechanical, electrical and plumbing systems. As with BOCA's comparison, issues identified for the Uniform Building Code center around construction means and methods. Both comparisons address corrosion of masonry, design of anchors, and design loads for breakaway walls. The NFPA comparison raised no issues in regard to amending its own codes. The comparison with manufactured housing codes and standards identified issues similar to the model code issues including the need to reference NFIP documents, utility protection, provisions for floodwalls and anchorage design criteria. The CABO 1 & 2 Family Dwelling comparison raised issues regarding the equalization of hydrostatic forces, and corrosion protection.

For FEMA documents the list of issues raised is considerably longer and displays ten themes which three or more code comparisons identified. Although each comparison presents these issues in different ways and suggests varying courses of action, the topic for each can be stated uniformly as follows:

1. Requiring a geotechnical report for any structural element bearing on soil including piers and piles

2. Coordinating wind loads and wind maps and referencing ASCE 7-88

3. Accounting for snow loads in design

4. Accounting for seismic loads in design

5. Supplying appropriate design values for various types of construction including wood construction, roof to wall connections, and floor beams to pile connections

6. Alternate means of construction, for example, types of shear walls, or wood post for pilings

7. Defining anchorage requirements

8. Application of wood preservatives, use of naturally durable wood and referencing ASTM standards

9. Load requirements for breakaway walls.

10. Occupancy in basements below the BFE

In addition to these ten, there are numerous other issues concerning the FEMA documents identified in at least two of the comparisons. This does not necessarily mean they are less important than the ten issues identified in three or more comparisons. For example:

- o Protection of electrical utilities was cited by both NFPA standards and the Standard Building Code comparisons.
- o Use of registered professionals for design was cited in the BOCA National Building Code and the Uniform Building Code comparisons.
- o Several common issues were defined by the Standard Building Code and CABO 1 & 2 Family Dwelling Code comparisons including:
  - Requirements for nailing and splicing
  - Stud length
  - Wind criteria for wall sheathing
  - Additional moment in piles produced by knee braces
  - Wind loads for windows and shutters

A third category includes the issues addressed by only one code group. For example, the comparison of manufactured housing codes and standards addresses FEMA's use of ground anchors. Other such issues are listed separately for each of the code comparisons below.

National Codes (BOCA)

As stated in the background chapter, the BOCA National Building Code has already adopted the majority of the NFIP building regulations into the main body of its Building Code as well as in the BOCA Mechanical, Plumbing and Fire Prevention Codes. Consequently, the comparison between the National Building Code and the NFIP standards and technical guidelines has resulted in a "check-off" list of final items to be reconciled.

For the BOCA National Building Code this list includes:

Design loads for breakaway walls
Use of fill
Corrosion protection for concrete and masonry
Scour around piles
Use of exterior plywood in subflooring
Flood water loads
Uplift and lateral forces for anchorage

Performance of interior wall finishes
Elevator equipment above the BFE

For the FEMA documents this list includes:

Requiring a geotechnical report for piers
Importance factor in wind forces
Corrosion protection for concrete and masonry
Use of registered professionals for tall structures
Application of wood preservatives
Wood posts
Roof design tables for sheathing and ponding
Design values for roof to wall connections
Footing design
Snow and wind loads
Reference standards for wood foundations
Including live loads in buoyancy considerations
Impact loads
Structural calculations for reinforced concrete slabs
Occupancy in basements below the BFE

In the above list of issues identified for FEMA documents, corrosion protection for concrete and masonry was the only issue unique to this comparison.

Standard Codes (SBCCI)

According to the background chapter, the Standard Building Code is the only model building code that has adopted all of the NFIP regulations. However, for its own code, SBCCI recognized outstanding issues related to mechanical, electrical and plumbing systems. For FEMA documents the comparison produced the longest list of suggested changes in relation to the other comparisons. Like the BOCA comparison, many of the suggested recommendations deal with construction means and methods.

Issues related to the Standard Building Code include:

Referencing FEMA documents for elevation of mechanical equipment and utilities
Referencing the Standard for Floodplain Management for mechanical and gas equipment, tank, utilities, and elevator equipment installations
Uplift of storage tanks
Sump and ejector pumps where gravity drainage is available
Air valves below the BFE
Referencing the Standard for Floodplain Management for plumbing, sewer and storm drain backflow valves and potable water protection

Issues related to the FEMA documents are:

Twelve foot spacing of concrete piers
Alternate means of construction for shear walls
Anchorage requirements

Nailing and splicing requirements
Use of naturally durable wood
Snow and seismic loads
Velocity pressures for tall structures
Referencing ASTM standards for wood preservation
Referencing ACI standards for masonry and concrete
Soils investigations for design of piles
Stud length
Wind criteria for wall sheathing
Additional moment in piles produced by knee braces
Wind loads for windows and shutters
Reference ASCE 7-88 for wind loads
Toe-nailing
Considerations for design of wood construction
Particle board for sheathing
Exposed ductwork
Referencing codes for exhaust installation clearances
Referencing codes for utility clearances
Acquiring building permits
Deletion of rule of thumb for floor beams
Clarifying design requirements for footings
Addressing wave impact on utilities
Providing parameters for substantial improvement of a structure
Occupancy in basements below the BFE

Issues related to both sets of documents are:

Manufactured housing in floodways and coastal high hazard areas
Consistency of criteria for residential and non- residential buildings

The issues related to both sets of documents are unique to this comparison. In the above list of issues identified for FEMA documents, toe-nailing and providing parameters for substantial improvement of a structure were the only issues unique to this comparison.

Uniform Codes (ICBO)

As stated in the background chapter, the Uniform Building Code recently added flood resistant design standards in an appendix chapter. The language is similar to that of the BOCA Code in that it only covers the construction related requirements of the NFIP. Despite the similarity of the UBC appendix to the flood provisions in BOCA, the UBC comparison raises a number of different issues. In addition, the UBC comparison identifies seven thematic issues which appear repeatedly in its recommendations for changes to FEMA documents. The first relates to issues identified by BOCA, the second and third relate to issues identified by BOCA, SBCCI and other comparisons. The next three issues are unique to this comparison. The last issue on referencing local codes was echoed by SBCCI, but for different building components.

ICBO's thematic issues are:

- For the design of any type of structure, or structural member a registered architect or engineer should be utilized.
- For any structural element bearing on soil, the design should be based on a geotechnical report prepared by a soils engineer.
- Where the FEMA documents specify a certain type of construction, other means of construction should be allowed as long as technical criteria for flood hazard reduction is satisfied.
- FEMA documents should emphasize that examples of design calculations are only examples.
- Specific manufacturers products should not be specified in FEMA documents.
- Standards referenced in the FEMA documents should represent the latest edition.
- FEMA should reference local codes where applicable.

In addition the comparison raises singular issues for the both the UBC and the FEMA documents. For the UBC these issues are:

The flood zones where UBC allows elevated structures
Use of a national standard to define a manufactured home
Leakage through windows
Corrosion of masonry and metals
Protection of openings above the BFE
Wind design velocities for anchors
Design considerations for floodwalls
Water penetration criteria for sealants
Higher design loads for breakaway walls

For FEMA documents these issues are:

Protection of wood
Use of only piles in coastal high hazard zones
Use of wood shear walls
Consideration of lateral loads for all structures
Design tables based on materials, not connections
Loading criteria for fasteners of breakaway walls
Definition of grade should conform to UBC
Water penetration criteria for sealants
Occupancy in basements below the BFE

In regard to breakaway walls, the comparison identifies some significant conflicts between the UBC and the FEMA documents in regard to use of space below the BFE. According to ICBO, the FEMA documents should not allow parking without breakaway wall, and allow temporary storage. This and the following issues for FEMA documents are unique to the ICBO comparison:

Definition of grade should conform to UBC
Water penetration criteria for sealants

NFPA Standards

The NFPA comparison represents possibly the first evaluation of documents written for protection from flood hazards in relation to those written for protection from fire hazards. Because of the focused nature for the NFPA standards, the number of issues identified in the comparison are less broad in scope than the comparisons involving model building codes. Issues identified for FEMA documents center around protection of electrical systems, anchoring and maintenance of tanks, fire ratings for breakaway walls and water tight doors and maintenance of interior finishes for different occupancies as defined by the code. No issues were identified for the NFPA documents.

For electrical systems, issues are as follows:

Suitability for corrosive environments
Secure fastening of service mounting
Sealing of underground installations against flooding
Locating switches and circuit breakers for accessibility
Drainage for electrical systems installed below the BFE
Grounded and labeled power outlets for pumps and motors

Manufactured Housing Codes and Standards

Like the NFPA standards, manufactured housing codes and standards have probably not been compared with documents written for protection from flood hazards. Despite the origin of manufactured housing codes and standards described in the background chapter, many of the results of this comparison are similar to the comparisons for the National, Standard, CABO 1 & 2 Family Dwelling, Uniform and NFPA codes.

For 4930.3, the MHCSS and the MHIM, issues identified in the comparison regarding manufactured housing codes and standards are as follows:

Addition of complete flood design criteria
Addition of provisions for floodwalls
Utility protection
Addition of option for floating structure
Referencing FEMA documents where necessary

For FEMA documents issues are:

Clarifying limits of clay soil use
Language on removable chassis
Alternate forms of construction
Load requirements for breakaway walls
Anchoring requirements
Use of ground anchors

Referencing ANSI 58.1
Design stresses due to lateral movement

For both manufactured housing and FEMA documents, issues to reconcile are:

Coordination of wind criteria
Definition of forces for anchorage
Load requirements for open foundations

For ANSI A225.1, Appendix C of the CABO 1 & 2 Family Dwelling Code, and NFPA 501A the issues identified in the comparison for these codes are as follows.

Flood design criteria for extended wall foundations
Design requirements for anchorage
Referencing FEMA documents

For FEMA documents issues are:

Designing piers per manufacturer's recommendations
Provision for different concrete pier sizes
Designing anchors per manufacturer's recommendations

For both manufactured housing related model codes and standards and FEMA documents, issues to reconcile are:

Coordination of wind criteria
Correction of pier footings for scouring
Design loads
Anchoring requirements
Referencing ANSI 58.1

In the above list of issues identified for FEMA documents, the following issues were unique to this comparison:

Clarifying limits of clay soil use
Language on removable chassis

CABO 1 & 2 Family Dwelling Code

This comparison identified two issues related to the CABO 1 & 2 Family Dwelling Code. For FEMA documents, the list of issues is similar in length and content to the Standard Building Code comparison.

The issue related to the CABO 1 & 2 Family Dwelling Code is:

equalization of hydrostatic forces
corrosion protection

Issues related to the FEMA documents are:

Expansion of the definition of manufactured housing of include dimensional parameters
Snow and seismic loads
Reference ASCE 7-88 for wind loads
Alternate means of construction for shear walls
Anchorage requirements
Nailing and splicing requirements
Deletion of rule of thumb for cantilevers
Use of naturally durable wood
Velocity pressures for tall structures
Referencing ASTM standards for wood preservation
Referencing ACI standards for masonry and concrete
Soils investigations for design of piles
Stud length
Wind criteria for wall sheathing
Additional moment in piles produced by knee braces
Wind loads for windows and shutters
Lateral support for grade beams
Design considerations for truss bracing
Shear walls for pile foundations
Design considerations for floor beams and piles
Particle board for sheathing
Updating wind maps
Site preparation requirements
vapor barrier requirements

In the above list of issues identified for FEMA documents, the following issues were unique to this comparison:

Expansion of the definition of manufactured housing of include dimensional parameters
Lateral support for grade beams
Shear walls for pile foundations
Site preparation requirements
vapor barrier requirements

CHAPTER 4

RECOMMENDED CHANGES TO FEMA DOCUMENTS

Recommended Changes to FEMA Documents Based on the BOCA National Codes

1. NFIP 44 CFR 59.1 (Elevated buildings) — BOCA National Building Code
   NFIP 44 CFR 60.3 ((c)(2), (c)(3), (e)(4), (e)(5), (e)(6))

   FEMA should provide direction to the model codes concerning the need to include the subclassification of flood zones (A1-30, AH, etc.) and B, C, X and D zones versus the current zones (A and V) found in the model codes. Upon resolution, changes to NFIP regulations and code changes to BOCA could be considered.

   See Appendix, pages A-2: item 4; A-5: items 2, 3; A-6: items 1, 2 3.

2. NFIP 44 CFR 59.1 (Breakaway wall) — BOCA National Building Code
   NFIP 44 CFR 60.3 ((e)(5))
   FEMA-55 (4.3.5.1, 4.3.5.2)

   FEMA should conduct the necessary research to support the 10-20 psf design loading for breakaway walls. A system designed in this load range may breakaway under a design wind condition. Upon resolution of this issue, it would then be appropriate to prepare a code change which reflects the results of the research as design criteria to be included in NFIP regulations and BOCA.

   See Appendix, pages A-1: item 4; A-6: item 2, A-26: item 2; A-27: item 1.

3. NFIP 44 CFR 60.3 ((e)(5)) — BOCA National Building Code
   FEMA-55 (4.3.5.1)

   FEMA may wish to clarify that break-away walls are allowed in A-zones provided the opening criteria is met. This would also be a viable option under the alternative approval provisions of BOCA.

   See Appendix, pages A-6: item 2; A-26: item 2.

4. NFIP 44 CFR 59.1 (Substantial improvement) — BOCA National Building Code

   The term "substantial improvement" used in FEMA is based on 50% of market value while BOCA's reconstruction or restoration provisions are a function of 50% of replacement cost. FEMA to evaluate whether the criteria to determine compliance should be based on "market value" or "replacement cost".

   See Appendix, page A-4: item 6.

5. FEMA-54 (Piers) — BOCA National Building Code
   FEMA-55 (4.3.1.1, Appendix D)

   FEMA should require soil testing and a geotechnical report prior to the placement of foundations to ensure sufficient load bearing capacity of the soil.

   See Appendix, pages A-10: item 1; A-18: item 2; A-34: item 2.

6. FEMA-54 (Pier foundation connections) — BOCA National Building Code
   FEMA-114 (3.13)

   Anchor bolt embedment differ slightly between BOCA and FEMA. If viewed as a conflict, FEMA would need to conduct an evaluation of the relevant standards to determine if a "correct" embedment can be ascertained.

   See Appendix, pages A-10: item 3; A-48: item 3.

7. FEMA-55 (4.1.1) BOCA National Building Code

It is recommended that FEMA revise its importance factor for wind from 1.11 to 1.05 for all buildings other than essential facilities and assembly buildings with less than 300 occupants. This will bring the importance factors into correlation with ANSI A58.1/ASCE 7-82 which is referenced by BOCA.

See Appendix, page A-14: item 2.

8. FEMA-54 (Building materials) BOCA National Building Code
FEMA-55 (4.1.2, 4.2.2, 4.2.3.1, 4.2.3.2, 4.2.3.3, 4.3.2.4) BOCA National Fire Prevention Code

It is recommended that FEMA include a general provision to address moisture protection. Suggested language is: Construction materials, including connections, shall be resistant to water damage such that conditions of corrosion, deterioration, or decay will not occur.

See Appendix, pages A-11: item 2; A-12: item 1; A-14: item 3; A-17: items 2, 3, 4, 5; A-20: item 4: A-80: item 1.

9. FEMA-55 (4.1.4) BOCA National Building Code

Registration laws for engineers and architects vary from state to state and FEMA should acknowledge these laws.

See Appendix, page A-15: item 3.

10. FEMA-55 (4.1.4) BOCA National Building Code

The requirements for professional registration (V-zones) require correlation with the NFIP regulations.

See Appendix, page A-15: item 3.

11. FEMA-55 (4.2.1.3) BOCA National Building Code

Main supporting members are critical to the structural integrity of a building but so are joists and other structural elements. It is not clear why FEMA only requires certain structural elements to be preservative treated.. FEMA should revise its' criteria to include a requirement for pressure preservative treatment for all structural members subject to flooding.

See Appendix, page A-16: item 4.

12. FEMA-54 (Building materials) BOCA National Building Code
FEMA-55 (4.2.1.4, 5.2)
FEMA-102 (Chapter III Part C)

FEMA should reference the appropriate standards for the pressure preservative treatment of wood. These include AWPA C1-88, C2-89 and C9-85 for above grade construction and AWPA C3-89, C4-89, AWPB MP1-88, MP2-88, and MP4-88 for timber piles. Preservatives should conform to AWPA P1-89, P2-89, P5-89, P8-89, and P9-87. Wood used in foundations should conform to AWPB-FDN-88.

See Appendix, pages A-11: item 2; A-12: item 1; A-17: item 1; A-31: item 3; A-43: item 1.

13. FEMA-55 (4.3.1.3) BOCA National Building Code
MCRB (III.A.1)

It seems overly restrictive to preclude the use of a building material. If adequately designed, wood posts (FEMA-55) or unreinforced masonry (MCRB) should be considered acceptable. It is recommended that FEMA relax their recommendation of material types in favor of a designed system of material of the designer's choice when such materials can be shown to be suitable for their intended use.

See Appendix, pages A-19: item 2; A-54: item 1.

14. FEMA-55 (4.3.2.8) — BOCA National Building Code

FEMA should include design tables for the maximum span of roof sheathing as well as ponding provisions for the design of flat and low-slope roofs. Alternatively, FEMA could reference the model codes for roof sheathing design tables.

See Appendix, page A-22: item 1.

15. FEMA-55 (4.3.3.4) — BOCA National Building Code

FEMA should revise their provisions to include a prohibition of shear or other walls which are part of the structural frame below the BFE in V-zones.

See Appendix, page A-24: item 2.

16. FEMA-55 (4.3.4.1)
FEMA-85 (Chapter IV Part A) — BOCA National Building Code

It is recommended that FEMA reference the wind and snow design values of ANSI A58.1/ASCE 7-82.

See Appendix, pages A-24: item 4; A-39: item 2.

17. FEMA-55 (4.3.4.4) — BOCA National Building Code

FEMA should reference the design standard for wood, namely, NFoPA NDS-1986 with 1987 revisions and 1988 Supplement - Design Values for Wood Construction.

See Appendix, page A-25: item 3.

18. FEMA-55 (4.3.7.2) — BOCA National Building Code

FEMA should determine the appropriate performance criteria for storm shutters and stipulate when and what type are required. This could then be considered by BOCA.

See Appendix, page A-29: item 1.

19. FEMA-55 (4.3.7.4) — BOCA National Building Code

FEMA should stipulate the locations which require flashing.

See Appendix, page A-29: item 3.

20. FEMA-54 (Building Materials and Wood, Steel, Concrete and Masonry)
FEMA-55 (5.2, 5.3)
MCRB (III.A.3, III.A.4, III.B.7.b) — BOCA National Building Code

FEMA should reference the applicable standards for plain and reinforced concrete design, ACI 318-89 and ACI 318.1-89, respectively. Concrete materials and admixtures should conform to ASTM C260-86, ASTM C618-88, and ASTM C989-89. Ready-mix concrete should conform to ASTM C94-89b or ASTM C685-89b.

See Appendix, pages A-11: item 2; A-12: item 1, A-31: items 3, 4: A-54: items 3, 4; A-57: item 4.

21. FEMA-85 (Chapter III-Fill)
FEMA-102 (Chapter III Part B) — BOCA National Building Code

FEMA-85 and -102 require coordination with the NFIP regulations relative to the use of structural fill in V-zones. NFIP regulations do not permit fill in V-zones.

See Appendix, pages A-37: item 1; A-42: item 3.

22. FEMA-85 (Chapter III-Elevated foundations) BOCA National Building Code

Pier height restrictions differ slightly between BOCA and FEMA. If viewed as a conflict, FEMA would need to conduct an evaluation of the relevant standards to determine if a "correct" pier height can be ascertained.

See Appendix, page A-37: item 2.

23. FEMA-85 (Chapter IV D) BOCA National Building Code

It is not clear how the recommendations found in FEMA would be implemented relative to providing a means of evacuation and/or rescue during a flood event. In all likelihood, compliance with these recommendations would preclude a structure from being built in an area prone to flooding. FEMA to evaluate.

See Appendix, page A-41: item 1.

24. FEMA-102 (Maintenance) BOCA National Building Code

FEMA should evaluate how the provisions in FEMA-102 correlate with the NFIP requirements relative to "substantial improvements".

See Appendix, page A-44: item 1.

25. FEMA-102 (Appendix D Part B) BOCA National Building Code
MCRB (III.C.4.g, V.B.1, I.B.4)

FEMA should provide data for determining floodwater depth and velocity for use in hydrostatic and hydrodynamic load calculations. This would include the conditions of flood water velocity, erosion, sediment, depth and watershed hydrology. If no such data exists, a research effort should be undertaken to establish such data as the basis to develop specific hydrodynamic design loads for incorporation into ASCE 7.

See Appendix, pages A-46: item 3; A-60: item 3; A-62: item 4; A-66: item 5.

26. FEMA-114 (3.5) BOCA National Building Code

FEMA-114 requires a revision to clarify when openings to equalize floodwaters are required (A-zones) versus breakaway walls (V-zones)

See Appendix, page A-48: item 1.

27. FEMA-114 (6.5) BOCA National Building Code
FEMA-54 (Building materials)
MCRB (III.A.1, III.A.2)

FEMA should reference the current masonry standard for unreinforced and reinforced masonry, ACI 530/ASCE 5-88. Masonry mortar should conform to ASTM C270-88a.

See Appendix, pages A-11: item 2; A-12: item 1, A-49: item 3; A-54: items 1, 2.

28. MCRB (III.A.6) BOCA National Building Code

FEMA should review the referenced standard for wood foundations (NFoPA TR7-87) to determine applicability to flooded conditions.

See Appendix, page A-55: item 1.

29. MCRB (III.B.4) BOCA National Building Code

The FEMA MCRB Manual discusses the design and construction of residential basement walls subjected to hydrostatic and hydrodynamic loads (i.e., below the BFE). Under BOCA, residential basements usable for human occupancy are required to be above the BFE. The BOCA codes does not permit the water-resistant design option for residential structures with floors usable for human occupancy below the BFE-this option is acceptable for all uses except residential. FEMA NFIP 44 CFR 60.3 (c)(2) also requires "residential structures...(including basements) elevated to or above the base flood level" - unless a variance is granted in accordance with NFIP 44 CFR 60.6. Therefore, FEMA should clarify the use of the MCRB with respect to residential basements.

See Appendix, page A-56: item 3.

30. MCRB (III.C.3) BOCA National Building Code

FEMA should review the calculations relative to the inclusion of live load in buoyancy considerations.

See Appendix, page A-59: item 4.

31. MCRB (III.C.5) BOCA National Building Code

The basis for FEMA's assertion that loads other than impact and debris will not "appreciably alter the designs recommended" requires substantiation. Additionally, the FEMA MCRB Manual takes the position that debris is not considered but other documents such as FEMA-54 (pages 69-70) and FEMA-55 (Section 4.1.3) require this type of loading to be evaluated. FEMA needs to clarify the effect this has on the use of the manual.

See Appendix, page A-60: item 4.

32. MCRB (V.A.2.h) BOCA National Building Code

FEMA presents an oversimplified view that a 6 inch thick reinforced slab is adequate (rebar size and placement not described). FEMA should either provide a series of prescriptive design solutions for a broad range of conditions or simply require structural calculations in accordance with the current edition of ACI 318-89.

See Appendix, page A-62: item 2.

33. FEMA Technical Bulletin 85-3 (Design Considerations) BOCA National Building Code

The 8th sentence under "Masonry walls" in 85-3 is probably incorrect for most conditions. This sentence states "Once the pins fail, the wall will cantilever with the reinforcing bars at the bottom of the wall, providing additional resistance to failure until the wall's capacity is reached." What is more likely, is that a load sufficient to cause the failure, in shear, at connecting pins at the top of the wall, can be expected to result in an immediate failure, in bending, at the bottom. We therefore recommend this statement be deleted or modified.

See Appendix, page A-72: item 3.

34. FEMA Technical Bulletin 88-2 (Flood Resistant Materials) BOCA National Building Code
FEMA-55 (4.3.2.4)

FEMA should conduct the necessary research to indicate in 88-2 which of the materials referenced by Section 2101.6.6 of the BOCA National Building Code will withstand direct and prolonged contact with flood waters without sustaining significant damage. The criteria by which significant damage is accessed is especially important to establish. Such information can then provide a technical basis for proposed changes to the model codes which will establish a regulatory basis for approving flood damage resistant material.

See Appendix, pages A-20: item 4; A-74: item 1.

Recommended Changes to FEMA Documents Based on the SBCCI Standard Codes

1. FEMA 54 (Posts, Post Embedment, Post Anchorage)
FEMA 55 (4.3.1.3 Posts Wood)
FEMA 102 (III. C. 2 Posts)
STANDARD BUILDING CODE

FEMA 54, FEMA 102, and FEMA 55 should combine post foundations and pile foundations into one section with more prescriptive requirements.

See Appendix, page B-4, items 1-3
See Appendix, page B-12, item 3
See Appendix, page B-29, item 3

2. FEMA 54 (Shear Walls and Floor Diaphragms)
STANDARD BUILDING CODE

FEMA 54 should address the use of shear walls and floor diaphragms as a method of bracing but should permit the building designer to choose the method.

See Appendix, page B-5, item 4

3. FEMA 54 (Pier Foundation Connection)
STANDARD BUILDING CODE

FEMA 54 should provide wind load values or forces for which the anchorage is adequate.

See Appendix, page B-5, item 5

4. FEMA 54 (Floor Beams)
FEMA 55 (4.2.1.2 Main Supporting Members)
STANDARD BUILDING CODE

FEMA 54 and FEMA 55 should provide better nailing and splice location requirements.

See Appendix, page B-6, item 1
See Appendix, page B-10, item 4

5. FEMA 54 (Cantilevers)
STANDARD BUILDING CODE

FEMA 54 should delete the "rule of thumb" or add better guidance for the design of the cantilever.

See Appendix, page B-6, item 2

6. FEMA 54 (Wood)
STANDARD BUILDING CODE

FEMA 54 should include "naturally durable wood."

See Appendix, page B-7, item 3

7. FEMA 54 (Performance Criteria) STANDARD BUILDING CODE
FEMA 55 (5.1 General Design Considerations)
FEMA 55 (G-7. Foundation Standards)
FEMA 55 (G-8. Anchoring Standards)
FEMA 114 (3.14 Technical Design Criteria Open Foundations)
FEMA 114 (Appendix C - Forces)
No. 85-2 (Flood Forces)
No. 85-3 (II Wind and Water Forces)
No. 88-1

FEMA 54, FEMA 55, FEMA 114, No. 85-2, No. 85-3, and No. 88-1 should address snow and seismic loads. The use of the phrases "unacceptable risks", "unacceptable health hazards", and "unacceptable magnitude" are too subjective. FEMA 114, No. 85-3, and No. 88-1 should update the wind speed maps to the latest editions and address snow and seismic loads. SBC should address hydrostatic, hydrodynamic, and buoyancy forces in floodplain areas.

See Appendix, page B-8, item 2
See Appendix, page B-17, item 4
See Appendix, page B-21, item 5
See Appendix, page B-22, item 3
See Appendix, page B-33, item 4
See Appendix, page B-35, item 4
See Appendix, page B-48, item 1
See Appendix, page B-49, item 1
See Appendix, page B-50, item 1

8. FEMA 55 (4.1.1 Wind) STANDARD BUILDING CODE
FEMA 55 (G-6. Determination of Loading Forces)
FEMA 55 (G-14. Reference Documents)
FEMA 85 (Design of Elevated Foundations)
FEMA 114 (Appendix C - Forces)
No. 85-3 (II Wind and Water Forces)
No. 88-1

FEMA 55, No. 85-3, and No. 88-1 should update reference to ASCE 7-1988. FEMA 85 and HUD 's MHCSS should update the wind and snow loads to ASCE 7-88. FEMA 85, No. 85-3, and No. 88-1 should address seismic loads. FEMA 114 should update the wind speed maps to the latest editions and address snow and seismic loads. SBC should address hydrostatic, hydrodynamic, and buoyancy forces in floodplain areas.

See Appendix, page B-9, item 1
See Appendix, page 21, item 4
See Appendix, page 25, item 3
See Appendix, page 27, item 1
See Appendix, page 35, item 4
See Appendix, page 49, item 1
See Appendix, page 50, item 1

9. FEMA 55 (4.1.4 Effects of Forces on Higher and Larger Structures) STANDARD BUILDING CODE

FEMA 55 should provide velocity pressures (psf) for varied wind speeds and building height.

See Appendix, page B-10, item 1

10. FEMA 55 (4.2.1.1 Pilings Wood) STANDARD BUILDING CODE

FEMA 55 should provide additional information such as ASTM standard preservative treatment and allowable stresses of timber piles.

See Appendix, page B-10, item 3

11. FEMA 55 (4.2.1.4 Wood Preservatives) STANDARD BUILDING CODE

FEMA 55 should list some of the AWPA standards.

See Appendix, page B-11, item 1

12. FEMA 55 (4.2.2 Masonry Materials and Concrete) STANDARD BUILDING CODE

FEMA 55 should add references to ACI 318 and ACI/ASCE 530.

See Appendix, page B-11, item 2

13. FEMA 55 (4.3.1.2 Piles) STANDARD BUILDING CODE

FEMA 55 should emphasize that type of pile, pile depth, and method of installation should be based on the soils investigation.

See Appendix, page B-12, item 2

14. FEMA 55 (4.3.1.4 Piers) STANDARD BUILDING CODE

FEMA 55 should clarify that the reinforcing, footing size, and grade beam size should be based on the design forces.

See Appendix, page B-12, item 4

15. FEMA 55 (4.3.2.2 Beams) STANDARD BUILDING CODE

FEMA 55 should provide nailing requirements for built-up members.

See Appendix, page B-13, item 1

16. FEMA 55 (4.3.2.3 Joists and Rafters) STANDARD BUILDING CODE

FEMA 55 should delete the reference to rafters or add information on rafters.

See Appendix, page B-13, item 2

17. FEMA 55 (4.3.2.4 Subflooring) STANDARD BUILDING CODE

The provisions are compatible. FEMA 55 should provide some recommended nail spacing and spans.

See Appendix, page B-13, item 3

18. FEMA 55 (4.3.2.5 Studs) STANDARD BUILDING CODE

FEMA 55 should address sizing of studs including number of stories which the stud supports or limits for the use of 2x4 studs.

See Appendix, page B-13, item 4

19. FEMA 55 (4.3.2.6 Wall Sheathing) STANDARD BUILDING CODE

FEMA 55 should provide additional information addressing the wind speed in addition to height above grade.

See Appendix, page B-14, item 1

20. FEMA 55 (4.3.2.7 Wall Bracing) STANDARD BUILDING CODE

FEMA 55 should combine 4.3.2.6 Wall Sheathing and 4.3.2.7 Wall Bracing into one section and address the design requirements for the wall bracing method chosen.

See Appendix, page B-14, item 2

21. FEMA 55 (4.3.3.1 Knee Braces) STANDARD BUILDING CODE

FEMA 55 should emphasize that the wood foundation piles should be designed for the additional moment introduced into the pile from the knee brace.

See Appendix, page B-14, item 5

22. FEMA 55 (4.3.3.2 Grade Beams) STANDARD BUILDING CODE

FEMA 55 should emphasize the need to design the grade beams to assure that they are actually providing lateral support of piles.

See Appendix, page B-15, item 1

23. FEMA 55 (4.3.3.3 Truss Bracing) STANDARD BUILDING CODE

FEMA 55 should emphasize the need to design the bracing members.

See Appendix, page B-15, item 2

24. FEMA 55 (4.3.3.4 Shear Walls) STANDARD BUILDING CODE

FEMA 55 should address wood shear walls for wood pile foundations.

See Appendix, page B-15, item 3

25. FEMA 55 (4.3.4.4 Floor Beam to File, Post, or Pier) STANDARD BUILDING CODE

FEMA 55 should provide some design values or wind speeds for which the connections are appropriate.

See Appendix, page B-15, item 5

26. FEMA 55 (4.3.7.1 Window Selection
FEMA 55 (4.3.7.2 Operable Shutters) STANDARD BUILDING CODE

FEMA 55 should address the design of the windows and shutters for the wind load pressures

See Appendix, page B-16, item 4
See Appendix, page B-16, item 5

27. FEMA 55 (4.3.7.4 Roofing Materials) STANDARD BUILDING CODE

FEMA 55 should emphasize the need to have a roof covering designed to withstand the uplift from the wind. SBC should emphasize that the roof covering should be designed to 1205.

See Appendix, page B-17, item 2

28. FEMA 55 (5.3 Slabs an Grade) STANDARD BUILDING CODE

The minimum slab thickness in FEMA 55 should be changed to 3 1/2 inches and delete the requirement for welded wire fabric.

See Appendix, page B-18, item 2

29. FEMA 55 (G-3. Scope) STANDARD BUILDING CODE

Since market value is a variable based on location, economy, etc., FEMA should require compliance for all improvements since noncompliance of any part of the structure makes the entire structure out of compliance.

See Appendix, page B-21, item 1

30. FEMA 55 (G-7.1 Pile Foundation Design) STANDARD BUILDING CODE

FEMA 55 should emphasize that pile spacing and embedment should be based on the foundation investigation. FEMA 55 should reduce the minimum compressive strength of the concrete for reinforced concrete piles to 4000 psi, since 4000 psi has been a building code requirements since 1980.

See Appendix, page B-22, item 1

31. FEMA 55 (G-8.1 Connector and Fasteners) STANDARD BUILDING CODE

FEMA 55 should not prohibit toe nailing if the connection is adequate for the calculated loads. SBC should address corrosion protection of metal connectors.

See Appendix, page B-22, item 4

32. FEMA 55 (G-8.2 Beam to Pile Connections)
FEMA 55 (G-8.5 Ceiling Joist Rafter) STANDARD BUILDING CODE

FEMA 55 should permit the designer to design the connection.

See Appendix, page B-23, item 1
See Appendix, page B-23, item 4

33. FEMA 55 (G-8.3 Floor to Deck Connections) STANDARD BUILDING CODE
FEMA 55 (G-8.4 Exterior Wall Connections)

FEMA 55 should permit the designer the leeway to meet performance requirements.

See Appendix, page B-23, item 2
See Appendix, page B-23, item 3

34. FEMA 55 (G-9. Roof Sheathing) STANDARD BUILDING CODE

FEMA 55 should permit particleboard roof sheathing provided it is of the appropriate strength.

See Appendix, page B-24, item 1

35. FEMA 55 (G-13. Certification Requirements) STANDARD BUILDING CODE

FEMA 55 should provide parameters for which sections 7 and 8 are appropriate (wind load, height above grade, etc.).

See Appendix, page B-25, item 2

36. FEMA 85 (Anchoring) STANDARD BUILDING CODE

FEMA 85 should address minimum number of ties and anchors.

See Appendix, page B-26, item 4

37. FEMA 102 (III.C.3 Piles) STANDARD BUILDING CODE

FEMA 102 should emphasize that the length and maximum design load is based on the foundation investigation and report.

See Appendix, page B-29, item 4

38. FEMA 102 (Table III-1 Minimum Requirements for Reinforced Piers) STANDARD BUILDING CODE

FEMA 102 should clarify the soil bearing capacity was used for the minimum footing size and the design loads used for the minimum pier size.

See Appendix, page B-30, item 2

39. MCRB (III.A.2 Reinforced and Grouted Block) STANDARD BUILDING CODE

MCRB should reference ANSI A41.2 and ACI/ASCE 530.

See Appendix, page B-37, item 2

40. MCRB (III.A.4 Reinforced Concrete) STANDARD BUILDING CODE

MCRB should reference ACI 318.

See Appendix, Page B-37, item 4

41. MCRB (III.B.9 Anchorage) — STANDARD BUILDING CODE

MCRB should be changed to comply with current model codes.

See Appendix, Page B-40, item 5

42. MCRB (III.C.5 Debris, Wind, Impact, Snow, Ice, and Other Live Loads) — STANDARD BUILDING CODE

MCRB should include wind, snow, and seismic loads.

See Appendix, Page B-42, item 5

43. MCRB (Ch. V Basements for Floods) — STANDARD BUILDING CODE
MCRB (A.2 Designs, Methods, and Tables)
MCRB (A.2.a Building Model, Dimensions, and Loading)
MCRB (A.2.b Structural Analysis Model) (Wall)
MCRB (A.2.c Structural Plain Concrete)
MCRB (A.2.d Reinforced Concrete)
MCRB (A.2.e Plain Masonry Block)
MCRB (A.2.f Reinforced Masonry Block)
MCRB (A.2.g Flood Waters Above Grade)
MCRB (A.2.h Slab Thickness) (Based on Bending)
MCRB (A.2.i Structural Slab Design) (Ultimate Strength Design)

MCRB should not reference a single model code. MCRB should reference only national consensus documents.

See Appendix, Page B-42, item 13

44. FEMA 54 (Insulation) — STANDARD MECHANICAL CODE

Change FEMA 54 to address insulation of exposed ductwork.

See Appendix, page B-59, item 3

45. FEMA 102 (Ch. IV Other Floodproofing Measures) — STANDARD MECHANICAL CODE

(1) Revise SMC to reference the Standard for Floodplain Management (2)) Revise FEMA 102 to reference the locally adopted model code for installation clearances.

See Appendix, page B-62, item 2

46. FEMA 102 (Appendix D "Floodproofing Performance Criteria") — STANDARD MECHANICAL CODE

(1) Revise FEMA 102 to reference the local model codes for access and clearance. (2) Revise SMC to reference Standard for Floodplain Management.

See Appendix, page B-62, item 4

47. FEMA 114 (Ch. 9 Protection of Utilities, 9.4 Permanent Protection Measures) — STANDARD MECHANICAL CODE

(1) Change FEMA to reference locally adopted model codes for clearances to combustible materials and minimum access (2) change the SMC to reference the Standard for Floodplain Management.

See Appendix, page B-64, item 2

48. FEMA 114 (Ch. 9 Protection of Utilities, 9.5 Utility Relocation to Existing Space) — STANDARD MECHANICAL CODE

Section 9.5 of FEMA 114 should be revised to reference minimum clearances for heat producing appliances according to local model codes.

See Appendix, page B-64, item 3

49. FEMA 114 (Ch. 9 Protection of Utilities, 9.6 Utility Relocations to New Space) — STANDARD MECHANICAL CODE

Section 9.5 of FEMA 114 should be revised to encourage obtaining a building permit for new construction/alterations. It should also reference model codes for minimum clearance to combustibles and access to equipment.

See Appendix, page B-64, item 4

50. FEMA 54 (Mechanical Equipment) — STANDARD GAS CODE

(1) Revise FEMA to caution that fuel-fired equipment must be installed to local codes (2) Revise SGC to reference the Standard for Floodplain Management.

See Appendix, page B-79, item 3

51. FEMA 55 (Ch. 4 - Structure Design, Section 4.3.6 Utilities)
FEMA 55 (Appendix G "Sample Coastal Construction Code" 12 Utilities)
FEMA 102 (Ch. IV Other Floodproofing Measures)
FEMA 102 (Appendix D "Floodproofing Performance Criteria) — STANDARD GAS CODE

(1) For elevation - revise the SGC to reference the Standard for Floodplain Management. (2) For fuel supply - revise FEMA 55 AND 102 to reference model codes for installation.

See Appendix, page B-81, item 1
See Appendix, page B-81, item 3
See Appendix, page B-83, item 2
See Appendix, page B-83, item 4

52. FEMA 114 (Ch.9 Protection of Utilities, 9.6 Utility Relocation to Existing Space) — STANDARD GAS CODE

FEMA 114 should be revised to reference readers to local model codes for other safety considerations.

See Appendix, page B-85, item 4

53. No. 90-3 (Section D-2) STANDARD GAS CODE

Revise No. 90-3 to reference the local model code for venting and combustion air.

See Appendix, page B-97, item 1

54. NFIP (60.3(b)(8) Manufactured Home Installation) STANDARD FOR FLOODPLAIN MANAGEMENT

In order to avoid confusion, NFIP and SFM should list the zone designation (A, AO, AH, VO, M, etc.) along with the word description (floodway, coastal high hazard)

See Appendix, page B-120, item 3

55. FEMA 54 (Posts, Post Embedment, Post Anchorage) STANDARD FOR FLOODPLAIN MANAGEMENT
FEMA 55 (4.3.1.3 Posts)

FEMA 54 and FEMA 55 should combine post foundations and pile foundations into one section.

See Appendix, page B-123, item 1
See Appendix, page B-129, item 2

56. FEMA 54 (Floor Beams, Cantilevers) STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 54 should delete the "rule of thumb".

See Appendix, page B-123, item 4

57. FEMA 54 (Performance Criteria) STANDARD FOR FLOODPLAIN MANAGEMENT
FEMA 55 (4.1.1 Wind)
FEMA 55 (5.1 General Design Considerations)
FEMA 55 (5.6 Exterior Wall Systems)
FEMA 114 (3.14 Technical Design Criteria Open Foundations)
FEMA 114 (Appendix C - Forces)
No. 85-3 (II Wind and Water Forces)
No. 88-1

FEMA 54, FEMA 55, FEMA 114, No. 85-3 and 88-1 should include performance criteria for snow and seismic loads. The use of the phrases "unacceptable risks", "unacceptable health hazards", and "unacceptable magnitude" are too subjective. FEMA 114 should update the wind speed maps to the latest edition. FEMA 55, No. 85-3 and No. 88-1 should update reference to ASCE 7-88. Section 801.1 of the Standard for Floodplain Management should reference Chapter 12 instead of only 1205 (Wind) to include 1204 (Snow) and 1206 (Seismic).

See Appendix, page B-125, item 1
See Appendix, page B-126, item 2
See Appendix, page B-132, item 2
See Appendix, page B-133, item 2
See Appendix, page B-143, item 4
See Appendix, page B-145, item 3
See Appendix, page B-156, item 1
See Appendix, page B-157, item 1

58. FEMA 55 (4.1.4 Effects of Forces on Higher and Larger Structures) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should provide velocity pressures (psf) for varied wind speeds and building height.

See Appendix, page B-127, item 1

59. FEMA 55 (4.2.1.2 Main Supporting Members, Beams, Wood) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should provide more specific parameters for which the stated nailing is appropriate.

See Appendix, page B-127, item 4

60. FEMA 55 (4.3.1.2 Piles) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should emphasize that the type of pile, pile depth, and method of installation should be based on the soils investigation.

See Appendix, page B-129, item 1

61. FEMA 55 (4.3.1.4 Piers) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should clarify that the reinforcing, footing size, and grade beam should be based on the design forces.

See Appendix, page B-129, item 3

62. FEMA 55 (4.3.2.3 Joists and Rafters) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should delete the reference to rafters.

See Appendix, page B-130, item 1

63. FEMA 55 (4.3.2.6 Wall Sheathing, 4.3.2.7 Wall Bracing) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should combine wall sheathing and wall bracing into one section and address the design requirements for the wall bracing method chosen.

See Appendix, page B-130, item 4

64. FEMA 55 (4.3.2.8 Roof Details, 4.3.3 Foundation Bracing, 4.3.4 Connections) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should provide some design values or wind speeds for which the connections and details are appropriate.

See Appendix, page B-130, item 5

65. FEMA 55 (4.3.6 Utilities) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should address the potential damage from high winds in coastal areas.

See Appendix, page B-131, item 2

66. FEMA 55 (G-6 Determination of Loading Forces)
FEMA 55 (G-14 Reference Documents)
FEMA 85 (Ch. IV Design of Elevated Foundations)
FEMA 114 (Appendix C - Forces)
No. 85-3 (II Wind and Water Forces)
No. 88-1

STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55, FEMA 85, HUD's MHCSS, No. 85-3 should update its reference to ASCE 7-88. FEMA 114 should update the wind speed maps to the latest edition and address snow and seismic loads. Section 801.1 of the Standard for Floodplain Management should reference Chapter 12 instead of only 1205 (Wind) to include 1204 (Snow) and 1206 (Seismic).

See Appendix, page B-136, item 2
See Appendix, page B-138, item 1
See Appendix, page B-140, item 1
See Appendix, page B-145, item 3
See Appendix, page B-156, item 1
See Appendix, page B-157, item 1

67. FEMA 55 (G-13 Certification of Requirements)

STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should provide parameters for which sections 7 and 8 are appropriate (wind load, height above grade, etc.)

See Appendix, page B-137, item 5

68. MCRB (III.C.5 Debris, Wind Impact, Snow, Ice and Other Live Loads)

STANDARD FOR FLOODPLAIN MANAGEMENT

MCRB should include wind, snow, and seismic loads.

See Appendix, Page B-149, item 1

69. MCRB (Chapter V Basements in Floods)
MCRB (A. Structural Design/Analysis)
MCRB (A.2 Designs, Methods, and Tables)
MCRB (A.2.a Building Model, Dimensions, and Loading)
MCRB (A.2.b Structural Analysis Model) (Wall)
MCRB (A.2.c Structural Plain Concrete)
MCRB (A.2.d Reinforced Concrete)
MCRB (A.2.e Plain Masonry Block)
MCRB (A.2.f Reinforced Masonry Block)
MCRB (A.2.g Flood Waters Above Grade)
MCRB (A.2.h Slab Thickness) (Based on Bending)
MCRB (A.2.i Structural Slab Design) (Ultimate Strength Design)

STANDARD FOR FLOODPLAIN MANAGEMENT

MCRB should not reference a single model code. MCRB should reference only national consensus documents.

See Appendix, Page B-149, item 2

Recommended Changes to FEMA Documents Based on the ICBO Uniform Codes

1. CFR 60.6 — Uniform Building Code
(c)(2)(i) (Flood-proof Walls)

Either the U.B.C. should provide provisions for residential basements or CFR 60.6 should not allow such basements.

See Appendix, page C-8, item 2.

2. FEMA-55 — Uniform Building Code

4.1.1 (Wind)

FEMA-55 should reference the latest edition of the Minimum Design Loads for Buildings and other structures published by the American Society of Civil Engineers (ASCE 7-88, formerly ANSI 58.1).

See Appendix, page C-10, item 1.

3. FEMA-55 — Uniform Building Code

4.1.2 (Corrosion Protection)

FEMA-55 should address roofing details and those of other exterior assemblies.

See Appendix, page C-10, item 2.

4. FEMA-55 — Uniform Building Code

4.2.1.3 (Other Wood Members)

FEMA-55 should require protection of all members that are exposed to these conditions.

See Appendix, page C-12, item 2.

5. FEMA-55 — Uniform Building Code

4.2.1.4 (Preservatives)

FEMA-55 should recommend that the wood preservatives meet approved national and local standards.

See Appendix, page C-12, item 3.

6. FEMA-55 Uniform Building Code

4.3.1 (Foundations)

FEMA-55 should recommend the use of only piles or columns in Coastal High Hazard Zones.

See Appendix, page C-12, item 4.

7. FEMA-55 Uniform Building Code

4.3.1.1 (Soil Conditions)

FEMA-55 should recommend the use of a licensed engineer for the classification of the soil or provide a reference to a document that does require such certification.

See Appendix, page C-14, item 1.

8. FEMA-55 Uniform Building Code

4.3.1.2 (Piles)

FEMA-55 should recommend that the sizing of the piles is done by a licensed engineer or architect or provide a reference to a document that does require such certification.

See Appendix, page C-14, item 2.

9. FEMA-55 Uniform Building Code

4.3.1.3 (Wood Posts)

FEMA-55 should allow the use of wood posts in A zones provided the foundation system is designed by a licensed engineer or architect.

See Appendix, page C-14, item 3.

10. FEMA-55 Uniform Building Code

4.3.1.4 (Masonry Piers)

FEMA-55 should recommend that a licensed engineer or architect design the pier foundation or provide a reference to a document that does require such certification.

See Appendix, page C-14, item 4.

11. FEMA-55 — Uniform Building Code

4.3.2.1 (Framing)
4.3.2.2 (Floor Beams)

FEMA-55 should recommend that the design of this type of framing system be done by a licensed engineer or architect, since these areas may also be subject to other lateral forces or provide a reference to a document that does require such certification.

See Appendix, page C-14, item 1.

12. FEMA-55 — Uniform Building Code

4.3.3 (Foundation Bracing)

FEMA-55 should recommend that a licensed engineer or architect design these braces and the rest of the foundation system or provide a reference to a document that does require such certification.

See Appendix, page C-17, item 1.

13. FEMA-55 — Uniform Building Code

4.3.3.2 (Grade Beams)

FEMA-55 should recognize other methods of foundation restraint.

See Appendix, page C-17, item 3.

14. FEMA-55 — Uniform Building Code

4.3.3.4 (Shear Walls)

FEMA-55 should address the use of wood shear walls as an acceptable method of resisting wind and water loads.

See Appendix, page C-18, item 1.

15. FEMA-55 Uniform Building Code

4.3.6 (Utilities)

FEMA-55 should also include the protection of utilities in the "A" flood hazard zone as they subject to similar conditions found in the Coastal High Hazard zone.

See Appendix, page C-20, item 4.

16. FEMA-55 Uniform Building Code

5.5 (Elevated Floors)

FEMA-55 should discuss composite floor systems as these are prevalent in high-rise construction.

See Appendix, page C-22, item 3.

17. FEMA-55 Uniform Building Code

Figure No. A-1 (Number of Piles)

FEMA-55 should recommend that a licensed engineer or architect design the piling system rather than provide specific design criteria for all situations or provide a reference to a document that does require such certification. Also, FEMA-55 should consider the soil conditions at the site when making design recommendations.

See Appendix, page C-23, item 2.

18. FEMA-55 Uniform Building Code

Table No. A-7 (Bolt Capacity of Floor Beam Connections)

FEMA-55 should base their design tables on the materials used in the connection as well as the type of connection.

See Appendix, page C-25, item 2.

19. FEMA-55 Uniform Building Code

B.1 (Knee Bracing)

FEMA-55 should recognize the use of other forms of bracing as well as requiring the use of a licensed engineer or architect in the design of such a system.

See Appendix, page C-27, item 2.

20. FEMA-55 Uniform Building Code

B.2.1.2 (Thread Bar Diagonals)
B.2.2 (Struts)

FEMA-55 should not recommend specific manufacturers.

See Appendix, pages C-28, items 2 and 3.

21. FEMA-55 Uniform Building Code

D.3 - Procedure A-3 (Minimum Embedment of Piles)

FEMA-55 should recommend that a soils engineer be consulted and a soils report be undertaken for each specific site as the soil conditions vary from site to site.

See Appendix, pages C-230, item 1.

22. FEMA-55 Uniform Building Code

Appendix G.4 (Definitions)

FEMA-55 should develop language that correlates the definition of "grade" with the U.B.C. Such as replacing the term "adjoining" with a specific distance from the building at which point the measurement is taken.

See Appendix, page C-33, item 1.

23. FEMA-55 Uniform Building Code

Appendix G.6.2 (Wind Loads)

FEMA-55 should include the latest edition of ANSI Standard A 58.1 which is now ASCE 7-88.

See Appendix, page C-34, item 2.

24. FEMA-55 Uniform Building Code

Appendix G.7.1 (Pile Foundation Design)

FEMA-55 should include a provision for soil investigations to determine the site soil conditions.

See Appendix, page C-34, item 4.

25. FEMA-55 Uniform Building Code

Appendix G.8.3 (Floor and Deck Connections)

FEMA-55 should consider other structurally adequate materials.

See Appendix, page C-36, item 2.

26. FEMA-55 Uniform Building Code

Appendix G.11 (Use of Space Below the Lowest Elevated Floor)

FEMA-55 should not allow enclosed space for vehicular parking unless it is provided by breakaway walls and should recognize that portable or temporary storage of items can be located there.

See Appendix, page C-38, item 1.

27. FEMA-54 Uniform Building Code

Post Embedment

FEMA-54 should recommend the use of a soils investigation report by a licensed soil engineer in the design of the foundation system.

See Appendix, page C-43, item 4.

28. FEMA-54 Uniform Building Code

Building Materials

FEMA-54 should not recommend specific manufacturers or industrial groups for the protection of building materials.

See Appendix, page C-43, item 4.

29. FEMA-54 Uniform Building Code

Wood

FEMA-54 should not recommend specific manufacturers.

See Appendix, page C-44, item 1.

30. FEMA-114 Uniform Building Code

3.14 (Open Foundations)

FEMA-114 should discuss the use of a soils engineer and soils report in determining the embedment length of piles and the soil-bearing pressure in flood-prone areas.

See Appendix, page C-47, item 1.

31. FEMA-114 Uniform Building Code

6.5 (Technical Design Criteria)

FEMA-114 should recognize the authority of the local building codes, rather than recommend the use of standards which may not be recognized by the jurisdiction.

See Appendix, page C-48, item 1.

32. Bulletin No. 85-1 Uniform Building Code

I. Definition

FEMA Bulletin No. 85-1 should state that this method of floodproofing is only acceptable for the retrofitting of existing buildings.

See Appendix, page C-78, item 1.

Recommended Changes to FEMA Document
Based on NFPA Standards

1. FEMA 44 (59.1 (c)) NFPA 70

Delete:
"400 square feet or less when measured at the largest horizontal projection."

See Appendix, page D-6, par 1.

2. FEMA 54 (Utility Service, Pages 92,93) NFPA 70

Add a qualification in utility services:
"Electrical conduits and cables are to be suitable for an expected wet environment and the corrosive environment presented by salt water and spray in coastal areas."

See Appendix, page D-6, par 2.

3. FEMA 54 (Service Mounting, Pages 92,93) NFPA 70

Add a sentence to read:
"Electric equipment shall be securely fastened to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used. Underground electric supply conduits or cables should not be fastened to walls, or structures intended to breakaway under flood conditions. NFPA 70, The National Electric Code should be consulted for full installation requirements."

See Appendix, page D-6. par 3.

4. FEMA 54 (Raceways, Pages 92,93) NFPA 70

Add the following:
"Electrical conduits supplying the structure when installed underground should be sealed. The sealant should be installed at a location in the system so arranged as to prevent entrance of water due to flood conditions. Underground electrical conduits or cables should be protected against damage from flooding or scouring by burying to a depth that will provide protection under expected flood conditions. NFPA 70, The National Electric Code in Section 230-8, 230-32, and 300-5 contain specific design guidelines."

See Appendix, page D-6, par 4.

5. FEMA 54 (Electrical service location, Pages 92,93) NFPA 70

Add the following:
"All switches and circuit breakers shall be located so that they can be operated from a readily accessible place. They should be located so that the center of the operating handle is not more than 6 1/2 feet above the floor or platforms. Where necessary, a platform may be installed to provide accessibility where devices are located above the flood plain."

See Appendix, page D-7, par 1.

6. FEMA 55 (4.36,par 5, sentence 2) NFPA 70

Insert:

"Since the enclosure or raceway for the electric utilities is subject to physical damage, it should be installed in rigid metal conduit, intermediate metal conduit, or schedule 80 rigid nonmetallic conduit."

See Appendix, page D-7, par 2.

7. FEMA 55 (5-1.3.1) NFPA 70

Add the following:

" Fire barrier requirements for property or life protection may require the maintenance of fire barriers to grade."

See Appendix, page D-11, par 2.

8. FEMA 85 (Chapter IV, Page 69, Utility Service) NFPA 70

Add the following:

"Electric equipment shall be securely fastened to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used. Underground electric supply conduits or cables should not be fastened to walls, or structures intended to break-away under flood conditions. Electrical supply conduits and cables should be suitable for the environment they are likely to be exposed."

See Appendix, page D-7, par 3.

9. FEMA 85 (Chapter IV, Page 69, Utility Service) NFPA 70

Add the following:

" Where electrical conduits supplying the structure are installed underground, the conduit should be sealed. The sealant should be installed at a location in the system so arranged as to prevent entrance of water due to flood conditions. Underground electrical conduits or cable should be protected against damage by burying them to a depth which would minimize their shifting under flood conditions. Means should be provided to protect electrical supply conduits emerging from underground to the bottom of the structure from floating debris during flood conditions. All switches and circuit breakers should be located so they can be operated from a readily accessible place. They should be located so that the center of the operating handle is not more than 6 1/2 feet above the floor or platforms. Where necessary, a platform may be installed to provide accessibility where devices are located above the flood plain."

See Appendix, page D-8, par 1.

10. FEMA 85-1 (II Protection Goals) NFPA 58

Revise to read:

"LP-Gas or liquid transfer should be performed in accordance with NFPA 58, Standard for the Storage and Handling of Liquified Petroleum Gases."

See Appendix, page D-5, par 1.

11. FEMA 85-1 (IV A.9, par 2) NFPA 70

Revise adding:

"Where electrical supply lines cannot be elevated above flood level, they should be installed to arrange for draining away from panelboards, controllers, switches, or other electrical equipment in accordance with NFPA 70, sections 110-1 and 110-17."

See Appendix, page D-8, par 2.

12. FEMA 85-1 (Protection of Interior Finishes) NFPA 101

Add the following:

" Interior finishes may have fire resistance requirements which must be met under other codes separate from water resistance requirements."

See Appendix, page D-13, par 1.

13. FEMA 85-3 NFPA 70

Refer to FEMA 55 utility requirements as they relate to breakaway walls.

See Appendix, page D-10, par 3.

14. FEMA 102 (page 11, par 2) NFPA 101

Add the following:

"The force to open doors under means of egress requirements should be maintained for exit doors. Latching requirements for exterior doors may include the use of fire exit hardware in educational or assembly occupancies."

See Appendix, page D-12, par 1.

15. FEMA 102 (Chapter IV D. Wet Floodproofing Techniques, par 4, sentence 2) NFPA 70

Add the following:

"Where electrical supply lines cannot be elevated above the Design Flood Level, they must be installed to arrange for draining away from panelboards, controllers, switches, or other electrical equipment."

See Appendix, page D-8, par 3.

16. FEMA 102 (General) NFPA (General)

Expand the definition of Building Code to include the referencing of other standards and codes to properly include NFPA Codes and Standards.

See Appendix, page D-12, par 2.

17. FEMA 114 (8.7, par 3, sentence 3) NFPA 70

Revise to read:

"The power receptacle outlet and associated equipment should be of the grounding type and be labeled and listed by a recognized testing laboratory."

See Appendix, page D-9, par 1.

18. FEMA 114 (9.3) NFPA 70B

Revise the section to reference NFPA 70B, Electrical Equipment Maintenance.

See Appendix, page D-9, par 2.

19. FEMA 114 (9.4) NFPA 70

Add the following:

"Where electric service conductors are located within flood level range, most type services can be installed to raise the electrical service above flood level range."

See Appendix, page D-9, par 3.

20. FEMA 114 (Chapter 9) NFPA 54

Add references to NFPA 54, National Fuel Gas Code.

See Appendix, page D-2, par 1.

21. FEMA 114 (9.4) NFPA 58

Add references to NFPA 58, Standard for the Storage and Handling of Liquefied Petroleum Gases.

See Appendix, page D-4, par 2.

22. FEMA 165 NFPA 58

Add references to NFPA 58, Standard for the Storage and Handling of Liquefied Petroleum Gases.

See Appendix, page D-4, par 3.

Recommended Changes to FEMA Documents Based on Manufactured Housing Codes and Standards

1. NFIP Regulations

Manufactured Home Construction & Safety Standards HUD Handbook 4930.3

Add a definition for "modular housing."

See Appendix, pages E-1, item 1, and E-3, item 1.

2. NFIP Regulations

Manufactured Home Construction & Safety Standards

Change §60.3(b)(8) as follows:

. . . Acceptable methods of anchoring for resistance to flood forces include the use of bolts, cables and ties to adequately designed foundations.

See Appendix, page E-1, item 1.

3. NFIP Regulations

Manufactured Home Construction & Safety Standards

In §60.3(a)(3), add to the end of (iv) . . . this provision is not applicable to manufactured housing.

See Appendix, page E-2, item 1.

Note that in the opinion of NCSBCS, FEMA 85 should be replaced with a new document, a more prescriptive, and thus more site-enforceable standard. The performance recommendations of FEMA 85 are too vague to enable jurisdictions to perform the kind of service expected. The recommendations that follow are in the spirit of the contractual agreement.

4. FEMA 85

Manufactured Home Construction & Safety Standards Manufactured Housing Institute Model Installation Manual

Change the first paragraph at the top of page 4 to read:

Manufactured homes have been designed for placement on permanent foundations. Care must be taken to assure the safe transfer of all loads (gravity, wind, and flood), so as to not distress the structure.

See Appendix, pages E-22, item 1, and E-36, item 1.

5. FEMA 85

Manufactured Home Construction & Safety Standards

On page 15, add a sentence to the first **Hydrodynamic forces** paragraph: ". . . downstream side. The illustration below shows the forces acting on a home installed with the floor below the Basic Flood Line. In order to comply with the NFIP, homes must be installed above the flood line. The foundations and anchorage must be installed to resist damage."

See Appendix, page E-23, item 1.

6. FEMA 85 — Manufactured Home Construction & Safety Standards

On page 22, change the caption for Figure 3.11 to include the statement: "Dry stacked blocks commonly approved by Manufactured Housing Producers are not acceptable under the NFIP."

See Appendix, pages E-23, item 4; E-25, item 3; E-26, item 1; and E-27, items 1-6.

7. FEMA 85 — Manufactured Home Construction & Safety Standards; Manufactured Housing Institute Model Installation Manual

Further research/study is recommended to determine the capacity of anchors under saturated soil conditions. In FEMA 85, on page 30, add a sentence to the end of the paragraph that ends at the top of the right column: "If test data or certified capacity charts are not available for saturated soil, the ground anchors should not be used."

See Appendix, pages E-24, item 1; E-25, item 5; E-31, item 4; E-38, item 2; and E-39, item 6.

8. FEMA 85 — Manufactured Home Construction & Safety Standards; Manufactured Housing Institute Model Installation Manual

On page 52, Figure 4.32, change the orientation of the ground anchor to show it coaxial with the cable and add the following to the caption:

Ground anchors must be installed as tested. Ground anchor tests are usually for anchors applied in the same axis as the cable. If test data or certified capacity charts are not available for applications in saturated soil, the ground anchors should not be used.

See Appendix, pages E-26, item 1, and E-40, item 1.

9. FEMA 85 — Manufactured Home Construction & Safety Standards

Further study is recommended on the structural procedures that are recommended in Appendix D. It appears that higher margins of safety against overturning and sliding may be appropriate.

See Appendix, pages E-28, item 4, and E-29, item 2.

10. FEMA 85 — Manufactured Home Construction & Safety Standards; HUD Handbook 4930.3

Further study is recommended to collect state-of-the-art test results for ground anchor applications in various types of soils, saturated, and unsaturated, as well as the effects of varying the angle of pull and use of concrete collars. The results of that effort should be used to update Appendix E.

See Appendix, pages E-29, item 1; E-31, item 4; and E-33, item 2.

11. FEMA 85 — HUD Handbook 4930.3

On page 5, add the following to the second from the last paragraph:

The design methods and procedures for flood damage abatement are contained in this manual.

On page 6, either eliminate the Type 2 System from Figure 1.13 or explain that this system is unstable and is not allowed.

See Appendix, page E-30, item 2.

12. FEMA 85

HUD Handbook 4930.3

Change the first paragraph, second column, page 18 to read as follows:

Because it is highly unlikely that maximum wind forces and maximum flood loads will occur simultaneously on one structure, designs should be prepared separately for the two loads (wind and flood). The most critical design is that which should be used.

See Appendix, page E-31, item 1.

13. FEMA 85

HUD Handbook 4930.3

Add a new paragraph beneath Figure 4.2 in column 2:

FEMA recommends that foundations designed to resist combinations of wind and flood loads be designed to resist the wind loads in ASCE-7.

See Appendix, pages E-31, item 6, and E-32, items 2 and 4.

14. FEMA 85

HUD Handbook 4930.3

Add a paragraph beneath the chart in column 2 of page 45:

The chart above was developed based upon test results for ground anchors in dry soil. FEMA recommends that ground anchors not be used for flooding conditions unless data for anchors in saturated soil is presented to the building official to show safe working loads of the anchors that exceed 2200#.

See Appendix, page E-32, item 3.

15. FEMA 85

Manufactured Home Construction & Safety Standards
HUD Handbook 4930.3

In Appendix E, change Table E.1 and add a footnote to Table E.1, page 99; place an asterisk next to each Water Height Difference >6" so that the headline reads:

1 2 3 4 5 6 9* 12* 42* 48*

* Floor-to-frame screw anchorage exceeds the wind uplift requirements of the Federal Manufactured Housing Construction and Safety Standards. Additional screws are needed. Use a screw design force equivalent to the T_v for the actual design minus T_v for 6" Difference in Water Height. Example: 24 Wide Home, 42" Water Height Difference, use 2380.8#-124.4#=2256#.

See Appendix, pages E-29, item 1, and E-33, item 2.

16. FEMA 85

CABO OTFDC, Appendix C

On page 22, add a last sentence to the paragraph above Figure 3.10:

Exception: The requirement for 30" burial can be waived in those situations where scouring is not expected. Place footings at a depth of 12", or the frost line, whichever is deeper.

See Appendix, page E-34, item 3.

6. FEMA 54 (Wood) CABO OTFDC

FEMA 54 should include "decay resistant wood."

See Appendix, page F-7, item 1

7. FEMA 55 (4.1.1 Wind) CABO OTFDC
FEMA 55 (G-14 Reference Documents)
FEMA 114 (Appendix C - Forces)
No. 85-3 (II. Wind and Water Forces)
No. 88-1

FEMA 55, No. 85-3, and No. 88-1 should update its reference and confirm that the wind load provisions are consistent with ASCE 7-88. The 1992 OTFDC does reference ASCE 7-88.
FEMA 114 should update the wind speed maps to the latest editions.

See Appendix, page F-9, item 2
See Appendix, page F-23, item 1
See Appendix, page F-28, item 5
See Appendix, page F-42, item 1
See Appendix, page F-43, item 1

8. FEMA 55 (4.1.4 Effects of Forces on Higher and Larger Structures) CABO OTFDC

FEMA 55 should provide velocity pressures (psf) for varied wind speeds and building height.

See Appendix, page F-10, item 1

9. FEMA 55 (4.2.1.2 Main Supporting Members Wood, Beams) CABO OTFDC

FEMA 55 should provide more specific nailing and splice details. OTFDC should provide more specific splice details.

See Appendix, page F-10, item 4

10. FEMA 55 (4.2.1.4 Wood Preservative) CABO OTFDC

FEMA 55 should list some of the AWPA standards.

See Appendix, page F-11, item 1

11. FEMA 55 (4.2.2 Masonry Materials and Concrete) CABO OTFDC

FEMA 55 should add reference to ACI 318.

See Appendix, page F-11, item 2

12. FEMA 55 (4.3.1.2 Piles) CABO OTFDC

FEMA 55 should emphasize that type of pile, pile depth, and method of installation should be based on the soil's investigation.

See Appendix, page F-12, item 3

13. FEMA 55 (4.3.1.4 Piers) CABO OTFDC

FEMA 55 should clarify that the reinforcing, footing size, and grade beam size should be based on the design forces.

See Appendix, page F-12, item 5

14. FEMA 55 (4.3.2.2 Beams) CABO OTFDC

FEMA 55 should provide nailing requirements for built-up members.

See Appendix, page F-13, item 2

15. FEMA 55 (4.3.2.3 Joists and Rafters) CABO OTFDC

FEMA 55 should delete the reference to rafters.

See Appendix, page F-13, item 3

16. FEMA 55 (4.3.2.4 Subflooring) CABO OTFDC

The provisions are compatible. FEMA 55 should provide some recommended nail spacing and spans. FEMA 55 should permit the use of particleboard subfloors.

See Appendix, page F-13, item 4

17. FEMA 55 (4.3.2.5 Studs) CABO OTFDC

FEMA 55 should address the length of the stud in addition to the number of stories which the stud supports.

See Appendix, page F-14, item 1

18. FEMA 55 (4.3.2.6 Wall Sheathing) CABO OTFDC

FEMA 55 should provide additional information addressing the wind speed in addition to height above grade.

See Appendix, page F-14, item 2

19. FEMA 55 (4.3.2.7 Wall Bracing) CABO OTFDC

FEMA 55 should combine 4.3.2.6 Wall Sheathing and 4.3.2.7 Wall Bracing into one section and address the design requirements for the wall bracing method chosen.

See Appendix, page F-14, item 3

20. FEMA 55 (4.3.3.4 Knee Bracing) CABO OTFDC

FEMA 55 should emphasize that the wood foundation piles should be designed for the additional moment introduced into the pile from the knee brace.

See Appendix, page F-15, item 1

21. FEMA 55 (4.3.3.2 Grade Beams) CABO OTFDC

FEMA 55 should emphasize the need to design the grade beams to assure that they are actually providing lateral support of the piles.

See Appendix, page F-15, item 2

22. FEMA 55 (4.3.3.3 Truss Bracing) CABO OTFDC

FEMA 55 should emphasize the need to design the bracing members.

See Appendix, page F-15, item 3

23. FEMA 55 (4.3.3.4 Shear Walls) CABO OTFDC

FEMA 55 should address wood shear walls for wood pile foundation.

See Appendix, page F-15, item 4

24. FEMA 55 (4.3.4.4 Floor Beam to Pile, Post, or Pier) CABO OTFDC

FEMA 55 should provide some design values or wind speeds for which the connections are appropriate.

See Appendix, page F-16, item 1

25. FEMA 55 (4.3.7 Wind and Storm Protection of Interior) CABO OTFDC
FEMA 55 (4.3.7.1 Window Selection)

FEMA 55 should reference the window standards and require the windows to be designed for the wind pressures.

See Appendix, page F-16, item 4
See Appendix, page F-17, item 1

26. FEMA 55 (4.3.7.4 Roof Materials) CABO OTFDC

FEMA 55 should emphasize the need to have the roof covering to withstand the uplift from the wind.

See Appendix, page F-17, item 4

27. FEMA 55 (G-3 Scope) CABO OTFDC

Since market value is a variable based on location, economy, etc., FEMA 55 should require compliance for all improvements since noncompliance of any part of the structure makes the entire structure out of compliance.

See Appendix, page F-20, item 1

28. FEMA 55 (G-6 Determination of Loading Forces) CABO OTFDC

FEMA 55 should update its reference to ASCE 7-88. FEMA 55 should also address snow and seismic loads. The 1992 OTFDC does reference ASCE 7-88.

See Appendix, page F-20, item 4

29. FEMA 55 (G-9 Roof Sheathing) CABO OTFDC

FEMA 55 should permit particleboard roof sheathing provided it is of the appropriate strength and does not deteriorate in the moist coastal environment.

See Appendix, page F-21, item 4

30. FEMA 55 (G-13 Certification Requirements) CABO OTFDC

FEMA 55 should provide parameters for which sections 7 and 8 are appropriate (wind load, height above grade, etc.

See Appendix, page F-22, item 4

31. MCRB (III.A.1 Unreinforced Block) CABO OTFDC
MCRB (III.A.2 Reinforced and Grouted Block)

MCRB should reference BIA and ACI/ASCE 530.

See Appendix, page F-30, item 1
See Appendix, page F-30, item 2

32. MCRB (III.A.4 Reinforced Concrete) CABO OTFDC

MCRB should reference ACI 318.

See Appendix, page F-30, item 4

33. MCRB (III.B.1 Basement Slab) CABO OTFDC

MCRB should provide site preparation requirements, minimum compressive strength, and vapor barrier requirements.

See Appendix, page F-32, item 1

34. MCRB (III.B.9 Anchorage) CABO OTFDC

The MCRB should be changed to comply with current model codes.

See Appendix, page F-34, item 1

35. MCRB (III.C.5 Debris, Wind, Impact, Snow, Ice, and Other Live Loads) CABO OTFDC

MCRB should include wind, snow, and seismic loads.

See Appendix, page F-35, item 5

36. MCRB (V.A. Structural Design/Analysis) CABO OTFDC
MCRB (V.A.2 Designs, Methods, and Tables)
MCRB (V.A.2.a Building Model, Dimensions, and Loading)
MCRB (V.A.2.b Structural Analysis Model (Wall))
MCRB (V.A.2.c Structural Plain Concrete)
MCRB (V.A.2.d Reinforced Concrete)
MCRB (V.A.2.e Plain Masonry Block)
MCRB (V.A.2.f Reinforced Masonry Block)
MCRB (V.A.2.g Flood Waters Above Grade)
MCRB (V.A.2.h Slab Thickness (Based on Bending))
MCRB (V.A.2.i Structural Slab Design (Ultimate Strength Design))

MCRB should not reference a single model code. MCRB should reference only national consensus documents.

See Appendix, page F-36, item 1

CHAPTER 5

RECOMMENDED CODE CHANGE LANGUAGE

Recommended Changes to the BOCA National Building Code

FEMA	BNBC	Analysis
NFIP 44 CFR 59.1 Technical Bulletin 85-3	1109.4 1112.0 2101.6.4.2	Both FEMA and BOCA require the wall to be capable of breaking away without effecting the structural integrity of the structure. FEMA requires break-away walls to resist wind loads but fail in response to combined wind and hydrodynamic loading. BOCA requires all structures to resist such loads except for coastal high-hazard zones where break-away walls are permitted. FEMA references ANSI A58.1, 1982 for wind loads. BOCA references ASCE 7, 1982, the same document by another name.

Recommendation: Provide exception to BOCA Section 1109.4 to address breakaway walls. See also recommendation to 44 CFR 60.3(e)(5).

Suggested Code Change:

1109.4 Hydrodynamic loads:

For buildings located in flood-hazard zones (A Zones) or high-hazard zones (V Zones), all structural components located below the base flood elevation shall be designed to resist hydrodynamic forces resulting from velocity waters during flooding to the base flood elevation.

Exception: Walls designed to break away or collapse as permitted in Section 2101.6.4.2.

FEMA	BNBC	Analysis
NFIP 44 CFR 60.3	2101.6.4.3	FEMA's provisions (Zone V) do not permit the use of fill for structural support. BOCA does not include this limitation. Also, the FEMA requirements include subclassifications of zones (i.e. V1, VE, etc) while BOCA addresses the zones as Zone V.

Recommendation: It would be appropriate to propose a revision to BOCA to include this prohibition. See also 44 CFR 59.1 - Elevated buildings.

Suggested Code Change:

2101.6.4.3 Foundations:

All buildings or structures erected in high-hazard zones shall be supported on pilings or columns and shall be adequately anchored to such pilings or columns. The piling shall have adequate soil penetration to resist the combined wave and wind loads (lateral and uplift) to which such piles are likely to be subjected during a flood to the base flood elevation. Pile embedment shall include consideration of decreased resistance capacity caused by scour of soil strata surrounding the piling. Pile system design and installation shall also be made in accordance with provisions of Section 1213.0 and 1214.0. Mat or raft foundations which support columns shall not be permitted where soil investigations required in accordance with Section 1202.1 indicate that soil material under the mat or raft is subject to scour or erosion from wave-velocity flow conditions. The use of fill for structural support shall be prohibited.

FEMA	BNBC	Analysis
FEMA-54, 55 Technical Bulletin 85-1 Technical Bulletin 88-2	1802.3 1801.4	BOCA states that steel shall be protected for exterior use with a shop or field coat to prevent corrosion. BOCA and FEMA require structural steel work and formed steel members to be corrosion protected but BOCA does not specifically address connectors. FEMA recommends the use of hot-dipped galvanizing for structural steel and the use of stainless steel. FEMA recommends regular inspection and maintenance of metal parts. No regular inspection parameters are stipulated in BOCA. FEMA recommends that the use of dissimilar metals be avoided due to potential for rapid corrosion.
	1502.6 1503.1 1503.3.2 1506.6.3	BOCA requires that admixtures, if used, shall follow requirements of ACI 318, ASTM C260, ASTM C618 and ASTM C989 depending on the type used. FEMA does not include requirements for the use of admixtures.
		BOCA cites that concrete shall be proportioned to provide the average compressive strength as prescribed by ACI 318, not less than 2500 psi. FEMA does not include the standard. FEMA acknowledges the effects of concrete exposed to salt laden air but does not provide criteria. BOCA prescribes minimum concrete properties (w/c, fc) for concrete exposed to sea water. BOCA and FEMA require increased concrete cover to reinforcement but neither stipulates the increase.
	1401.11 1402.6	FEMA acknowledges the effects of salt laden air on mortar but does not provide types of mortar which are acceptable. BOCA also does not prescribe specific masonry mortar types for masonry exposed to salt laden air. BOCA requires that mortar is to comply with ASTM C270.
	1701.1 1702.1 1703.2.6 1704.1.1 1702.5.3 (Supp) Appd. C	BOCA requires that pressure treated wood shall conform with standards AWPA C1, C2 and C9. BOCA references NFoPA NDS which requires galvanized sheet for metal plate connector joints (8.10.3). BOCA requires galvanized steel connections when the frame is more than one story in height and the studs are not continuous from the sill to the roof. FEMA requires all connections to be corrosion resistant. FEMA states that wood shall be treated to resist fungus, insects, bacteria, and rot and the treatment must be designed to keep water out. FEMA and BOCA's preservative treated wood fastener requirements similar.

FEMA	BNBC	Analysis
		FEMA recommends either 1x4 or 1x6 boards laid diagonally over joists or exterior type plywood following the guidelines of APA "Plywood Construction Guide". BOCA includes floor sheathing tables. FEMA stipulates an exterior glue while BOCA requires exterior, waterproof type plywood in all exterior uses, but allows either interior type, moisture-resistant type, or exterior type in interior applications. BOCA does not stipulate glue between layers for plywood. FEMA stipulates annular ring nails or deformed shank nails while BOCA's recommended fastening schedule (Appendix C) permits common nails.
	2103.3.10	Flashing requirements similar.
	2102.5	BOCA requires that exterior walls of alternative materials be weather-resistant but does not mention corrosion resistance.
	2101.6.6 2101.6.3.3	BOCA includes a general performance regulation which requires "All buildings... shall be constructed with materials resistant to flood damage..." BOCA makes no explicit provision to evaluate finishes intended to be periodically submerged. FEMA requires finishes to withstand immersion for 160 hours without damage.
	1901.1	FEMA recommends a 0.7 mil. anodizing finish and/or vinyl finish for aluminum elements such as doors, windows, gutters and flashings. BOCA references AA-SAS30 and AA-ASM35 for aluminum used for structural purposes. No similar requirements.

Recommendation: Both codes acknowledge the effects salt laden air and moisture have on building components. FEMA and BOCA require corrosion resistant fasteners for pressure treated wood but neither provide definitive criteria for masonry or concrete. It is recommended that FEMA include a general provision to address moisture protection and BOCA revise its current text. Suggested language is: Construction materials, including connections, shall be resistant to water damage such that conditions of corrosion, deterioration or decay will not occur.

Additionally, FEMA should consider referencing the applicable standards for wood preservatives, concrete and masonry. Also, BOCA should include performance related text to address FEMA requirements for finishes.

Suggested Code Change:

2101.6.6 Construction materials, methods, and practices:

All buildings or structures erected on flood-hazard zones (A zones) or in high-hazard zones (V Zones) shall be constructed with materials resistant to flood damage and be constructed by methods and practices that minimize flood damage. Construction materials, including connections, shall be resistant to water damage such that conditions of corrosion, deterioration or decay will not occur ~~in accordance with the provisions of Sections 1207.0, 1209.2, 1224.4, 1603.4, 1702.1.1, 1702.3, 1702.6.2 and 1702.6.6~~. Interior wall finishes and trim subject to direct contact with flood waters shall be of a type able to withstand inundation for a minimum of 160 hours without damage.

FEMA	BNBC	Analysis
FEMA-55	1219.0 1218.0	FEMA recommends minimum timber pile sizes and cites the advantages of square vs. round piles. FEMA recommends concrete piles when higher capacity or longer lengths are needed. BOCA does no stipulate minimum timber pile sizes but rather relies on a design. BOCA specifies a minimum lateral dimension for precast concrete piles of 10". BOCA relies on a designed system to support the loads.
	1213.0 1214.0 2101.6.4.3	FEMA cites the effects pile embedment has on the structural capacity of the pile. FEMA provides recommended pile penetrations. BOCA does not stipulate minimum pile embedments, but rather relies on a design. BOCA requires pile embedment to consider scouring in high hazard zones (V Zone) only.
	1215.0 1219.0	FEMA provides details of typical methods to install piles. BOCA does not prescribe the installation details for piles with the exception of cast-in-place concrete piles.

Recommendation: FEMA requires scour around piles to be evaluated for all pile installations while BOCA specifically cites scour for V Zones. It is recommended that BOCA include text for A Zones similar to that for V Zones relative to scour.

Suggested Code Change:

2101.6.3.2 Anchorage:

The structural system of all buildings or structures shall be designed, connected,and anchored to resist flotation, collapse, or permanent lateral movement due to structural loads and stresses from flooding equal to the base flood elevation and shall be designed in accordance with Sections 1109.3 and 1109.4. Foundation design shall include consideration of decreased structural capacity and stability caused by scour of soil strata surrounding the foundation system.

FEMA	BNBC	Analysis
FEMA-114	2101.6.3.2 2101.6.4.3 1703.2.11	Anchor bolts of a 1/2" diameter with a maximum spacing of 4 feet and an embedment depth of 18" are required by FEMA. BOCA's embedment depths are 8" (concrete) and 15" (grouted masonry). The total reaction force due to hydrostatic, hydrodynamic and/or impact loads must be transferred through anchor bolts into the supporting system. FEMA permits expansion anchors as a equivalent means of anchorage. BOCA includes performance criteria which requires the anchors to resist floatation, collapse or lateral movement. However, BOCA's anchorage provision for wood specifies that the anchorage must resist wind uplift and the maximum spacing is 8 feet.

Recommendation: BOCA should revise the provisions of Section 1703.2.11 to reference the design as being capable of resisting both uplift and lateral forces due to flooding (and wind). See also FEMA-54-Pier foundation connections.

Suggested Code Change:

('92 Supp) 1703.2.11 Foundation anchorage:

Wall sill plates, minimum of 2-inch by 4-inch members, shall be sized and anchored to foundation walls or piers and at intermediate intervals as required to resist wind uplift. Wall sill plates located below the base flood elevation in accordance with Section 2101.6 shall be sized and anchored in accordance with Section 1109.4. Foundation anchorage shall be by the use of anchor bolts or other approved anchoring method. Anchor bolts shall be a minimum diameter of 1/2 inch. The bolts shall be embedded in foundations to a depth of not less than 8 inches (203 mm) of poured-in-place concrete, and not less than 15 inches (381 mm) in grouted unit masonry. There shall be a minimum of two anchor bolts per section of plate and anchor bolts shall be placed 12 inches (305 mm) from the end of each section of plate with intermediate bolts spaces a maximum of 4 feet (1219 mm) on center.

Exception: All buildings or structures located in seismic map areas having a peak velocity-related acceleration (A_v) equal to or less than 0.05 in accordance with Section 1113.1 and buildings of Use Group R-3 located in seismic map areas having a peak velocity-related acceleration (A_v) less than 0.15 and agricultural storage buildings which are intended only for incidental human occupancy are permitted to have maximum intermediate bolt spacing of 8 feet (2438 mm).

FEMA	BNBC	Analysis
Technical Bulletin 88-4	2101.6.5	FEMA recommends that elevator equipment be located above the BFE or be water-resistant. Further, elevators should be interlocked to ensure that the cab automatically stays above flood water. BOCA requires all mechanical/electrical equipment to be placed above the BFE or protected to prevent water entering the equipment or system during floods up to the BFE.

Recommendation: Add a subsection to BOCA 2606.2 "Emergency operation of elevator" to require elevators to automatically move to a predetermined level above the BFE in the event of flooding.

Suggested Code Change:

('92 Supp) 2606.2.4 Activation in the event of flooding:

In areas prone to flooding an approved float switch shall be interlocked with the control circuit so that the elevator cab automatically rises to the first level above the base flood elevation.

FEMA	BNBC	Analysis
Technical Bulletin 90-4	120.4 620.3.1 2101.6 2101.6.3.2 2101.6.4.3 2101.6.5 2101.6.7 2101.6.9	FEMA requires manufactured (mobile) homes to be placed so that the lowest floor is either above the BFE, or placed on 36" piers (above grade), or in an existing park. FEMA describes various foundation/anchorage methods and speaks to soil bearing capacity and proper embedment of piles to resist scour. FEMA requires that any encroachments into a floodway be certified that such encroachment would not raise the BFE. Such provisions which prescribe acceptable land use are outside the scope of the BOCA Code. BOCA requires manufactured housing to be designed and built to resist the same flood forces as site built, which does not provide for 36" piers and/or placement below the NFE for residential occupancies.

Recommendation: To create separate and conflicting performance requirements for factory-built structures simply because they are not constructed on-site is contrary to BOCA's code development history and resulting policy on this matter. Therefore no recommendation is made to carry FEMA's separate treatment of manufactured housing into BOCA code text. Recommendation is made however, to revise BOCA Code Section 620.3.1 to refer to flood forces and/or reference Section 2101.6.7 of the BOCA Code.

Suggested Code Change:

620.3.1 Anchorage and tie-down:

Every parking space for mobile units shall be provided with devices for anchoring the unit to prevent overturning or uplift. The owner of the parking space shall anchor or cause to be anchored all mobile units located on the parking space. Where concrete platforms are provided for the parking of mobile units, anchorage shall be provided by eyelets embedded in the concrete with adequate anchor plates or hooks, or other suitable means. The anchorage shall be adequate to withstand forces and uplift as required in Article 11 for buildings and structures, based upon the size and weight of the units, and elevated as required by Section 2101.6.7 for flood prone areas.

Recommended Changes to the SBCCI Standard Codes

Standard Building Code

NFIP	SBC	Analysis
60.3(b)(8) Manufactured Home Installations	H105.3	NFIP requires manufactured homes to be installed to resist flotation, collapse, and lateral movement to minimize flood damage in addition to anchoring requirements for wind. SBC requires only anchorage for wind.

Recommendation: None since SBC does not address flotation as a force. Appendix H should reference the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

H105.3.6 Floodplain For manufactured homes located within the regulatory floodplain, refer to the SBCCI Standard for Floodplain Management.

FEMA 55	SBC	Analysis
4.2.3.2 Steel(Page 4-11)	Chapter 15	FEMA 55 addresses the problem of corrosion of unprotected steel shapes and anchoring devices (nails, bolts, etc.) and the need for regular inspection, maintenance, and replacement of corroded metal parts. SBC requires the design of steel construction to comply with the appropriate standards. SBC does not address corrosion in coastal environments.

Recommendation: SBC should address corrosion protection in coastal areas.

Suggested Code Change [or addition]:

1502 PROTECTION FROM CORROSION

Structural steel exposed directly to the weather or subject to salt corrosion in coastal areas shall be hot-dipped galvanized after fabrication.

(Renumber existing 1502 through 1511)

FEMA 55	SBC	Analysis
4.3.7.4 Roofing Materials (Page 4-54)	1205.1 3202	FEMA 55 emphasizes the need to use self-sealing, heavyweight shingles to avoid the possible loss of roofing material in high winds. SBC requires all parts of the building to be designed to withstand the appropriate wind loads.

Recommendation: FEMA 55 should emphasize the need to have a roof covering designed to withstand the uplift from the wind. SBC should emphasize that the roof covering should be designed to 1205.

Suggested Code Change [or addition]:

3202.1.1 Roof coverings shall be designed to withstand the minimum design loads in Chapter 12.

(Renumber existing 3202.1.1 and 3202.1.2)

FEMA 102	SBC	Analysis
Appendix D Floodproofing Performance Criteria Appendix D.B Design Loads (Pages 182-186)	Chapter 12	FEMA 102 lists the type of loads which the floodproofed structure may be subjected. SBC requires the structure to be of sufficient strength to support the loads and forces encountered.

Recommendation: None since both FEMA 102 and SBC require the structure to be designed for the loads and forces encountered. SBC should address hydrostatic, hydrodynamic, and buoyance forces in floodplain areas.

FEMA 114	SBC	Analysis
6.2 Considerations (Floodwalls) (Pages 111-114)	1201.1	FEMA 114 addresses the use of floodwalls to protect structures from flooding and emphasizes that tremendous forces are created by high water levels and velocities. SBC does not address floodwalls but does require structures to be designed for the loads and forces encountered.

Recommendation: SBC should address hydrostatic, hydrodynamic and buoyance forces in floodplain areas.

FEMA 114	SBC	Analysis
Appendix C - Forces (Pages 197-207)	Chapter 12	FEMA 114 addresses hydrostatic loads, hydrodynamic loads, impact loads, and wind loads. FEMA 114 also provides definitions, application and methodology for design. SBC requires design for all forces encountered but does not provide methodology. Section 900.4 of the SBCCI Standard for Floodplain Management addresses hydrostatic and hydrodynamic loads.

Recommendation: FEMA 114 should update the wind speed maps to the latest editions and address snow and seismic loads. SBC should address hydrostatic, hydrodynamic, and buoyancy forces in floodplain areas.

Suggested Code Change [or addition]:

1209 FLOODPLAIN

1209.1 General
For construction located within the regulatory floodplain, refer to the SBCCI Standard for Floodplain Management.

1209.2 Structural Safety
In addition to the minimum design loads of this chapter, provisions shall be made for hydrostatic, hydrodynamic, and buoyancy forces.

FEMA 55	SBC	Analysis
4.1.2 Salt Air, Moisture, and Wind-Driven Rain (Pages 4-7, 4-8)	1703	FEMA 55 provides general discussion of the hazards of salt air, moisture, and wind-driven rain on wood, bolts, nails, and connectors. SBC requires wood subject to damage from decay and termites to be naturally durable or pressure treated. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: SBC should address corrosion.

FEMA 55	SBC	Analysis
G-8.1 Connector and Fasteners (Page G-5)	1201.1	Both FEMA 55 and SBC require the connectors to support the loads and forces encountered. FEMA 55 does not permit toe nailing. FEMA 55 requires metal connectors and fasteners to have corrosion protection.

Recommendation: FEMA 55 should not prohibit toe nailing if the connection is adequate for the calculated loads. SBC should address corrosion protection of metal connectors.

FEMA 55		SFM	Analysis
G-8	Anchoring Standards	601.1	Both FEMA 55 and SFM all components to be securely fastened and adequately interconnected to resist the loads anticipated during flooding. FEMA 55 requires corrosion protection for connectors in exposed locations. SFM does not address corrosion protection.
G-8.1	Connector and Fasteners	801.1	
G-8.2	Beam to Pile Connections	801.3	
G-8.3	Floor to Deck Connections		
G-8.4	Exterior Wall Connections		
G-8.5	Ceiling Joist/Rafter Connections		
G-8.6	Projecting Members		
(Pages G-5, G-6)			

Recommendation: SFM should address corrosion protection of metal connectors.

Suggested Code Change [or addition]:

1705.4 Floodplain Areas

Metal plates, connectors, screws, bolts, and nails exposed directly to the weather or subject to salt corrosion in coastal areas shall be stainless steel or hot-dipped galvanized, after the fastener or connector is fabricated.

Standard Mechanical Code

NFIP	SMC	Analysis
60.6 – Variances and Exceptions 60.6(c)(2)(i) Flood-Proof Wall	302 303	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SMC allows underflow installation but does not specify minimum elevations for equipment. This is addressed in 602.1.2, 602.5, and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: The SMC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 54	SMC	Analysis
Mechanical Equipment (Page 93, Paragraph 2)	302 303	FEMA 54 requires all mechanical equipment to be elevated above expected flood waters, with indoor components preferably installed in attics. The SMC allows attic installation but does not specify minimum elevations for equipment.

Recommendation: These sections of the SMC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 55	SMC	Analysis
Chapter 4 - Structural Design Section 4.3.6 Utilities (Pages 4-50 to 4-52)	Ch. 3 607 607.3.1.5 302 303	FEMA 55 requires all mechanical equipment to be elevated above BFE, and fuel piping be on the leeward side of columns/piers or enclosed in shaft. The SMC allows attic installation of equipment, but does not specify minimum elevations for equipment. The SMC requires fuel piping to be supported and protected from physical damage.

Recommendation: (1) For equipment location - the SMC should be revised to reference the SBCCI Standard for Floodplain Management (2) for fuel pipe protection - None both address the issue only in different directions. FEMA - prescriptive SMC - performance.

FEMA 55	SMC	Analysis
Appendix G "Sample Coastal Construction Code" 12. Utilities (Page G-8)	302 303	FEMA 55 requires all mechanical equipment to be elevated above expected flood waters. The SMC allows such installations, but does not specify minimum equipment elevations.

Recommendation: The SMC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 102	SMC	Analysis
Ch. IV Other Floodproofing Measures C. Utilities (Pages 99-105)	302 303	FEMA 102 requires mechanical equipment to be elevated above BFE or "floodproofed". Floodproofing entails a watertight enclosure, with all penetrations into the building pressure sealed. The SMC allows such installations, with proper access and clearance to combustibles.
	308	FEMA 102 requires mechanical exhaust fans discharging below the BFE to be protected by flood shields. The SMC requires exhaust to discharge outdoors at a point where it "will not cause a nuisance" or 10 ft. above a public walkway.

Recommendation: (1) Revise SMC to reference the SBCCI Standard for Floodplain Management (2) Revise FEMA 102 to reference the locally adopted model code for installation clearances.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (A) Location (Page 192)	302 303	FEMA 102 requires that all mechanical equipment be installed above BFE, or be enclosed in water-tight rooms. The SMC allows elevated or enclosed installation but requires access and clearance to combustibles.

Recommendation: (1) Revise FEMA 102 to reference the local model codes for access and clearance. (2) Revise SMC to reference the SBCCI Standard for Floodplain Management.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (B) Heating and Air Conditioning (Page 192)	607	FEMA 102 requires that fuel systems below the BFE be equipped with automatic shutoff valves activated by rising water. The SMC would not require or prohibit such valves.
	306.2	FEMA 102 requires all heating equipment be vented to a level above BFE. SMC requires vent/chimney termination 3 ft. above roof and 2 ft. higher than any portion of the roof within 10 ft.

Recommendation: Revise SMC to reference the SBCCI Standard for Floodplain Management.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (C) Ventilation (Page 193)	307 308 Ch. 5	FEMA 102 requires all ductwork located below BFE to slope to drainage openings. The SMC does not require conditioned air ducts to slope for drainage.
	Ch. 5	FEMA 102 requires all ductwork located below BFE to be anchored against floodwaters. The SMC requires adequate support per SMACNA, or ASHRAE.
	510	FEMA 102 requires all penetrations of the building envelope by air ductwork to have a closure assembly. The SMC requires fire dampers at certain firewalls.

Recommendation: The SMC should be revised to reference the SBCCI Standard Floodplain Management.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (D) Fuel Tanks and Lines (Page 193)	607	FEMA 102 requires that fuel tanks and lines to be located above BFE or anchored and protected from floodwater velocity/surge with a factor of safety of 1.5. The SMC allows installation of fuel storage tanks either inside or outside buildings but does not address uplift forces. The SMC states that the piping shall be protected from physical damage.

Recommendation: The SMC should reference tank location, uplift forces, and the SBCCI Standard for Floodplain Management.

FEMA 114	SMC	Analysis
Ch. 9 Protection of Utilities 9.4 Permanent Protective Measures (Pages 160-163)	Ch. 3	FEMA 114 requires utility connections to be above flood level shielding for basement appliances, elevated installation for exterior appliances, suspension for underfloor equipment, and anchoring for fuel storage tanks. The SMC allows these types of installations but requires minimum clearances to combustibles and access which is ignored by FEMA 114.

Recommendation: (1) Change FEMA to reference locally adopted model codes for clearances to combustible materials and minimum access (2) changes the SMC to reference the SBCCI Standard for Floodplain Management.

FEMA 114	SMC	Analysis
Ch. 9 Protection of Utilities 9.8 Storage Tank Anchorage (Page 166)	607	FEMA 114 requires anchorage of fuel storage tanks. The SMC allows installation of fuel storage tanks inside or outside structures, but does not specifically address uplift forces.

Recommendation: Revise the SMC to reference the SBCCI Standard for Floodplain Management and add a section of fuel tank anchorage.

No. 85-1	SMC	Analysis
IV. Guidelines for implementation A10 HVAC (Page 11)	302 303	No. 85-1 requires that mechanical equipment either be elevated or enclosed for protection. The SMC allows enclosed installations, but does not specify minimum elevations for equipment.

Recommendation: The SMC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 88-4	SMC	Analysis
Recommendation #1 (Page 3)	Ch. 3	No. 88-4 requires location of elevator equipment above base flood elevation. The SMC allows such installation but does not specify minimum equipment elevations.

Recommendation: Revise the SMC to reference the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

301.4 Equipment Installed in Floodplain Areas
All mechanical equipment and related accessories installed in the regulatory floodplain shall be installed to satisfy this code and the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

607.4 Fuel Tanks
Fuel storage tanks installed in the regulatory floodplain shall be installed above the base flood elevation or anchored and protected from uplift and forces due to velocity/surge pressure with a 1.5 or greater factor of safety. Fuel storage tanks and fuel supply lines shall be installed to satisfy the SBCCI Standard for Floodplain Management.

NFIP	SGC	Analysis
60.6 – Variances and Exceptions 60.6(c)(2)(i) Flood-Proof Walls	Chapter 4	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SGC defers to the SMC for access and clearance, but does specify minimum combustion air and venting criteria. Utility location and floodproofing are addressed in 602.1.2, 602.5, and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: The SGC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 54	SGC	Analysis
Figure 4.48 Protective Utility Shaft (Page 92)	Ch.3 308	FEMA 54 requires gas piping serving an elevated structure to be installed on the leeward side of post/columns or enclosed in a protective shaft. The SGC requires piping to be supported and allows a shaft enclosure.

Recommendation: The SGC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 54	SGC	Analysis
Mechanical Equipment (Page 93, Paragraph 2)	Ch. 4 402.4	FEMA 54 requires all gas-fired mechanical equipment to be elevated above expected flood waters with indoor components preferably installed in attic. The SGC defers to the SMC for access and clearance, but does specify minimum combustion air and venting criteria. Ductwork is covered in the SMC.

Recommendation: (1) Revise FEMA to caution that fuel-fired equipment must be installed to local codes (2) Revise SGC to reference the SBCCI Standard for Floodplain Management.

FEMA 55	SGC	Analysis
Chapter 4 - Structural Design Section 4.3.6 Utilities (Pages 4-50 to 4-52)	Ch. 3, 308 Ch. 4, 402.4	FEMA 55 requires all gas-fired equipment to be elevated above expected flood water and gas piping to be installed on the leeward side of posts/columns or enclosed in shafts. The SGC defers to the SMC for access requirements, but does specify minimum combustion air and venting. The SGC requires piping to be supported and would allow the shaft.

Recommendation: (1) For elevation revise the SGC to reference the SBCCI Standard for Floodplain Management (2) For fuel supply - revise FEMA to reference model codes for installation.

FEMA 55	SGC	Analysis
Appendix G "Sample Coastal Construction Code" 12 Utilities (Page G-8)	Ch. 4	FEMA 55 requires all gas-fueled mechanical equipment to be elevated above flood waters. The SGC allows elevated installations but also requires minimum combustion air and venting criteria.

Recommendation: (1) Revise SGC to reference the SBCCI Standard for Floodplain Management. (2) Revise FEMA 55 to reference local model codes for installation.

FEMA 102	SGC	Analysis
Chapter IV Other Floodproofing Measures C. Utilities (Pages 99-105)	402 611	FEMA 102 gas-fired mechanical equipment to be elevated above "BFE" or "floodproofed." Floodproofing entails a watertight enclosures for equipment with all penetrations of the building envelope pressure sealed. The SGC allows equipment enclosure with proper access. Adequate combustion air and proper venting.
	611	FEMA 102 requires exterior gas natural draft vents below BFE to be protected by flood shields. The SGC allows very limited exterior venting.

Recommendation: (1) Revise the SGC to reference the SBCCI Standard for Floodplain Management (2) Revise FEMA 102 to reference the locally adopted model code for installation criteria.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning and Ventilation (A) Location (Page 192)	Ch. 4 402.4	FEMA 102 requires that all gas-fired mechanical equipment be installed above BFE, or be enclosed in water-tight rooms. The SGC allows elevated or enclosed installation, but specifies minimum combustion air and venting.

Recommendation: (1) Revise SGC to reference the SBCCI Standard for Floodplain Management. (2) Revise FEMA to reference locally adopted model codes for installation requirements.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (B) Heating and Air Conditioning (Page 192)	Ch. 4 Ch. 5 Ch. 6 608.3	FEMA 102 requires that gas delivery systems installed below BFE be equipped with automatic shutoff valves, activated by rising water. The SGC would not require or prohibit such valves. FEMA 102 requires all gas heating equipment be vented to a level above BFE. The SGC requires natural draft gas vents to terminate at least 2 ft. above roof and 2 ft. above any portion of the roof within 10 ft.

Recommendation: Revise SGC to reference the SBCCI Standard for Floodplain Management.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (D) Fuel Tanks and Lines (Page 193)	Ch. 3 Ch. 9	FEMA 102 requires fuel storage tanks and lines to be located above BFE or anchored and protected against floodwaters by a factor of safety of 1.5. The SGC does not address uplift forces on storage tanks.

Recommendation: (1) Revise SGC to reference the SBCCI Standard for Floodplain Management; and address buoyancy forces on storage tanks.

FEMA 114	SGC	Analysis
Ch. 9 Protection of Utilities 9.4 Permanent Protective Measures (Pages 160-163)	Ch. 4 Ch. 5	Section 904 of FEMA 114 requires utility connections to be above flood level, shielding for basement appliances, elevated exterior appliances, suspension for underfloor equipment and anchoring of fuel storage tanks. The SGC allows such installation but requires adequate combustion air and venting.

Recommendation: Revise SGC to reference the Standard for Floodplain Management.

No. 85-1	SGC	Analysis
IV. Guidelines for Implementation A.10 HVAC (Page 11)	Ch. 4 Ch. 5	No. 85-1 requires gas-fired mechanical equipment to be elevated or enclosed for protection. The SGC allows enclosed installation but requires combustion air and clearances to combustible construction.

Recommendation: The SGC should be revised to reference the Standard for Floodplain Management.

Suggested Code Change [or addition]:

301.1 Fuel Supply in Floodplain Areas
All fuel-fired equipment installed in regulatory floodplain shall be installed to satisfy this Code and the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

401.1 Installations of Fuel-fired Equipment in the Floodplain
All fuel-fired equipment installed in regulatory floodplain shall be installed to satisfy this Code and the SBCCI Standard for Floodplain Management.

FEMA 114	SGC	Analysis
Ch. 9 Protection of Utilities 9.8 Storage Tank Anchorage (Page 166)	Ch. 3	Section 9.8 of FEMA 114 requires anchorage of fuel storage tanks. The Sgc does not address uplift on LPG tanks.

Recommendation: Revise SGC to address uplift on LPG storage tanks.

Suggested Code Change [or addition]:

903.3 Fuel Tanks

Fuel storage tanks installed in the regulatory floodplain shall be installed above the base flood elevation or anchored and protected from uplift and forces due to velocity/surge pressure with a 1.5 or greater factor of safety. Fuel storage tanks and fuel supply lines shall be installed to satisfy the SBCCI Standard for Floodplain Management.

NFIP	SPC	Analysis
60.6 – Variances and Exceptions 60.6(c)(2)(i) Floodproof Walls	301.12 1204.1	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SPC prohibits deleterious discharge of sewage or other waste and requires the water distribution system to be protected against backflow. This is addressed in 602.1.2, 602.6, 602.7, and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 54	SPC	Analysis
Figure 4.48 Protective Utility Shaft (Page 92)	407	FEMA 54 requires water and DWV piping serving an elevated structure to be attached to the leeward side of posts/columns or enclosed in a protective shaft. The SPC requires piping to be protected from physical damage.

Recommendation: The SPC should be revised to reference the SBCCI for Floodplain Management.

FEMA 54	SPC	Analysis
Septic Tanks (Page 93, Paragraph 3)	Appendix E 301.12	FEMA 54 requires that septic tanks be floodproofed to stop floating and potential discharge of effluent. The SPC requires proper installation and prohibits deleterious discharge.

Recommendation: None since both approach the problem from different directions. FEMA - prescriptive SPC - performance. The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 55	SPC	Analysis
Chapter 4 - Structural Design Section 4.3.6 Utilities (Pages 4-50 to 4-52)	407	FEMA 55 requires water and DWV piping serving elevated structures to be attached to the leeward side of posts/columns or enclosed in a protective shaft. The SPC requires piping be protected from physical damage.

Recommendation: The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 55	SPC	Analysis
Appendix G "Sample Coastal Construction Code" 12 Utilities (Page G-8)	301.10 808 Ch. 13	FEMA 55 requires sanitary sewer and storm drainage systems with openings below the BFE to have backflow valves where the lines pass through the building envelope. The SPC requires a backwater valve only where a drainage system may be subject to a backflow sewage.

Recommendation: Revise the SPC to reference the SBCCI Standard for Floodplain Management and include specific criteria for the isolation of these lines.

FEMA 102	SPC	Analysis
Chapter IV Other Floodproofing Measures C. Utilities (Pages 99 - 105)	1302 1308	FEMA 102 requires that backwater valves be installed on the building sewer at a point where the piping is strong enough to resist the flood induced pressures. A backwater valve is usually a swing-check valve. As an alternate, all gravity sewer openings below the BFE may be routed to a sump, then pumped above BFE to the lowest entrance to the sewer (Figure IV - 8). FEMA also requires wells to be equipped with a watertight casing that extends from one ft. above grade to 25 ft. below grade to minimize contamination. The SPC would allow the backwater valve, but would prohibit the sump in situations where gravity sewer is available. (1308.1) The SPC does not address well construction.

Recommendation: (1) Revise SPC to reference the SBCCI Standard for Floodplain Management. (2) Revise SPC to allow sumps and ejectors for flood areas even where gravity drainage is available.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria" Criteria #7 "Plumbing Systems" (B) Sanitary Sewer Systems (Page 193)	301.10	FEMA 102 requires on-site sewage disposal systems to be designed to minimize floodwater effects. Sanitary sewer systems which must remain in operation during a flooding event should be designed with a sealed holding tank sized at 150% of anticipated demand. All vents should extend above BFE. The SPC will allow, in limited instances, air admittance valves in lieu of venting termination above roof.

Recommendation: Revise SPC to reference the SBCCI Standard for Floodplain Management and to prohibit air admittance valves below BFE.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (C) Water Supply Systems (Page 193)	1204	FEMA 102 requires that potable water supply systems be protected from contamination during flooding. The SPC requires protection of potable water.

Recommendation: The SPC should reference the SBCCI Standard for Floodplain Management.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (D) Backflow Prevention (Page 193)	301.10 Ch. 13	FEMA 102 requires backwater valves on storm drain, sewage and potable water supply lines installed at wells or building exits. The SPC allows such valves but only requires them for sewage backflow.

Recommendation: Revise the SPC to reference the SBCCI for Floodplain Management.

MCRB	SPC	Analysis
Chapter III Basement Construction (Pages 13-75) Chapter V Basements in Floods (Page 88-126) Chapter VII Appendix A-Soils Data (Pages 164, 166) Chapter VIII Builder's Guide (Pages 198, 206, 209, 211-262) Hydraulic/Hydrologic Manual (Pages 7-10)	301.12 1204.1	The majority of the MCRB does not address plumbing. However, III.B.8 does address plumbing materials, sewer systems, and potable water supply systems. MCRB requires gate valves on the sanitary sewer outlets from the house, and the potable water supply system to be designed in such a manner to prevent contamination from flood waters. The SPC prohibits deleterious discharge of sewage or other waste and requires the water distribution system to be protected against backflow. This is addressed in 602.6 and 602.7 of the SBCCI Standard for Floodplain Management.

Recommendation: The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

No. 85-1	SPC	Analysis
A.11 Plumbing and Water (Not in Scope) (Page 12)	Ch. 12 1204 301.10	No. 85-1 Section A.11 requires that interruptible water supply sources be protected from contamination by a check valve. The SPC does require backflow prevention. No. 85-1 requires a sealed holding tank for those disposal systems required to remain in operation during a flooding event. Sewage systems should have a manual valve or a backwater valve at building penetration. The SPC requires a backflow valve for sewage reversal only.

Recommendation: (1) Revise SPC to reference the SBCCI Standard for Floodplain Management; (2) Revise SPC to add a principle for flood plain areas.

No. 90-3	SPC	Analysis
Section D-2 (Pages 1-6)	N/A	No. 90-3 requires utilities to be (1) above design flood or (2) completely enclosed by the building's watertight walls or (3) be completely watertight. The SPC would not prohibit such installation, but only regulates size of space for setting fixtures.

Recommendation: Revise SPC to reference the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

301.23 Principle No. 23
All plumbing systems in the regulatory floodplain shall be installed to satisfy this Code and the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

1308.1 Building Drains Below Sewer
Building drains which cannot be discharged to the sewer by gravity flow shall be discharged into a tightly covered and vented sump from which the liquid shall be lifted and discharged into the building gravity drainage system by automatic pumping equipment or by any equally efficient method approved by the Plumbing Official.

EXCEPTION: In the regulatory floodplain where gravity drainage sewers are below the base flood elevation, a sump and ejector system satisfying this section and the SBCCI Standard for Floodplain Management may be used.

Suggested Code Change [or addition]:

1403.2.3 In regulatory floodplain, all vent terminals shall be above the base flood elevation or protected in accordance with the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

E101.4 All septic tanks installed in the regulatory floodplain shall be in conformance with both this Code and the SBCCI Standard for Floodplain Management.

FEMA 54	SFC	Analysis
Septic Tanks (Page 93, Paragraph 3)	501.2 602.7	FEMA 54 requires septic tanks to be floodproofed to prevent the tank from rising out of the ground. FEMA 54 and SFM requires the tank to be designed to minimize or eliminate discharge of effluent into the floodwaters.

Recommendation: SFM should address buoyancy forces on tanks.

Suggested Code Change [or addition]:

602.7 Sanitary Sewage Systems
New and replacement sanitary sewage systems shall be designed to resist flotation and to minimize or eliminate infiltration of flood waters into the system and discharges from the system into flood waters.

FEMA 55		SFM	Analysis
G-8	Anchoring Standards	601.1	Both FEMA 55 and SFM all components to be securely fastened and adequately interconnected to resist the loads anticipated during flooding. FEMA 55 requires corrosion protection for connectors in exposed locations. SFM does not address corrosion protection.
G-8.1	Connector and Fasteners	801.1	
G-8.2	Beam to Pile Connections	801.3	
G-8.3	Floor to Deck Connections		
G-8.4	Exterior Wall Connections		
G-8.5	Ceiling Joist/Rafter Connections		
G-8.6	Projecting Members		

(Pages G-5, G-6)

Recommendation: SFM should address corrosion protection of metal connectors.

Suggested Code Change [or addition]:

1705.4 Floodplain Areas

Metal plates, connectors, screws, bolts, and nails exposed directly to the weather or subject to salt corrosion in coastal areas shall be stainless steel or hot-dipped galvanized, after the fastener or connector is fabricated.

FEMA 114	SFM	Analysis
9.8 Storage Tank Storage (Page 166)	N/A	FEMA 114 addresses the need for proper anchorage of tanks to prevent their flotation from the buoyancy forces. SFM does not address anchorage of storage tanks.

Recommendation: SFM should address anchorage of storage tanks.

Suggested Code Change [or addition]:

602.8 Storage Tanks
Storage tanks shall be properly anchored to prevent movement and discharges from the tank into flood waters.

No. 88-1	SFM	Analysis
Pages 1-5	801.1	Both No. 88-1 and SFM address wind loads. No. 88-1 contains a reference to ANSI A58.1-1982. SFM references 1205 of the Standard Building Code which contains basic wind speed map, velocity pressure, and coefficients in addition to referencing ASCE 7-88.

Recommendation: No. 88-1 should update reference to ASCE 7-88 and address snow and seismic loads. Section 801.1 of the Standard for Floodplain Management should reference Chapter 12 instead of only 1205 (Wind) to include 1204 (Snow) and 1206 (Seismic).

Suggested Code Change [or addition]:

801.1 Anchoring
All new construction and substantial improvements within an area identified as a coastal high hazard area shall be elevated on pilings or columns in accordance with 800.2, and securely anchored to resist flotation, collapse and permanent lateral movement due to the effects of wind, snow, seismic, and water loading values shall be that which equals or exceeds the 100 year recurrence interval. The minimum design ~~wind loading values~~ loads shall be that specified in ~~Section 1205~~ Chapter 12 of the Standard Building Code.

Recommended Changes to ICBO Documents

FEMA-55	U.B.C.	Analysis
4.2.2-Masonry	Chapters 23 and 26 Appendix Chapter 23, Division IV.	FEMA-55 has a brief paragraph on the use of masonry and concrete in corrosive environments. The U.B.C. has specific design requirements for concrete on corrosive environments but does not address masonry in similar situations.

Recommendation: The U.B.C. should discuss the use of masonry in corrosive environments.

Suggested Code Change: Section 2393 (e), first sentence. Revise as follows: When buildings or structures . . . . components and the protection of all exposed elements from corrosion. Balance to remain unchanged.

Also: Section 2394 (e), first sentence. Revise as follows: When buildings or structures . . . . and connection components to comply with the requirements of Section 2394 (d) and showing the protection of all elements from the effects of corrosion. Balance of paragraph to remain unchanged.

FEMA-55	U.B.C.	Analysis
4.2.3.1-Aluminum	Chapter 28 Appendix Chapter 23.	FEMA-55 discusses the protection of aluminum trim, windows, etc. in corrosive environments. The U.B.C. does not address the use of these types of aluminum products in corrosive situations.

Recommendation: The U.B.C. should address the protection of all materials exposed to corrosive environments in Appendix Chapter 23.

Suggested Code Change: See suggested code change for 4.2.2.

FEMA-55	U.B.C.	Analysis
4.2.3.2- Steel	Chapter 27 Sec. 2510.	FEMA-55 discusses the protection of exposed steel in corrosive environments and recommends regular inspection and maintenance of same. The U.B.C. does not discuss the protection of steel members.

Recommendation: See recommendation for Section 4.2.3.1.

Suggested Code Change: See suggested code change for 4.2.2.

FEMA-55	U.B.C.	Analysis
4.3.7- 4.3.7.1 4.3.7.2 4.3.7.3 4.3.7.4- Protection of the Interior	Sec. 1708 Sec. 2516 Sec. 3201 Sec. 3205 Sec. 4205 Appendix Chapter 23, Division IV.	FEMA-55 discusses the protection of the interior of a structure from wind and water action. The U.B.C. requires that openings below the base flood elevation (BFE) be protected and that exterior assemblies provide a weather-resistive barrier.

Recommendation: The U.B.C. should address the protection of openings above the BFE from wind and water action.

Suggested Code Change: Section 2396. Add Subsection (g). (g) Protection of Openings. Openings subject to wind driven rain and wave action shall be watertight to protect the interior from water damage.

FEMA-55	U.B.C.	Analysis
Appendix G.8 Anchoring Standards	Appendix Chapter 23, Division IV Appendix Chapters 24 and 25.	FEMA-55 requires that the entire structural system be tied together to prevent flotation collapse or a permanent lateral movement due to a base flood event concurrent with the one-hundred-year design wind velocity. The U.B.C. requires that the structural system of a building or structure shall be tied together to resist the flotation, collapse, or permanent lateral movement due to loads to flooding equal to the base flood elevation. Another provision requires that the structure be designed and tied together to resist basic wind speeds from 80 to 110 miles per hour.

Recommendation: The U.B.C. should consider one-hundred-year design wind velocities concurrently with the base floor elevation forces.

Suggested Code Change: Section 2396 (b). Revise first sentence as follows: ". . . and hydrostatic loads and one-hundred-year design wind speeds."

FEMA-55	U.B.C.	Analysis
Appendix G.10 Protection of Openings	None.	FEMA-55 requires that exterior openings be designed and detailed to withstand high wind speeds and recommends additional protection such as storm shutters. The Uniform Building Code has no such provision.

Recommendation: The Uniform Building Code should address the protection of exterior openings from wind and water action that are above the base flood elevation.

Suggested Code Change: See suggested code change for 4.3.7.

FEMA-55	U.B.C.	Analysis
Appendix G.11.2 Certification of Breakaway Walls	Appendix Chapter 23, Division IV.	FEMA-55 allows the use of breakaway walls designed for greater loads than twenty pounds per square foot if designed by a licensed architect or engineer. The Uniform Building Code does not allow the use of breakaway walls that are designed above twenty pounds per square foot.

Recommendation: The Uniform Building Code should recognize that the design of breakaway walls with a higher loads considered may be appropriate under certain circumstances.

Suggested Code Change: Section 2396 (f). Add a sentence as follows: Higher breakaway wall loads may be used when approved by the building official.

FEMA-54	U.B.C.	Analysis
Steel	Chapter 1 Chapter 27 Appendix Chapter 23, Division IV.	FEMA-54 discusses the protection of steel structural members that are exposed to a corrosive environment. The U.B.C. does not have a specific requirement for the protection of steel. Rather, it requires that a structure be maintained in a safe condition which also has been interpreted as being protected from corrosive environments.

Recommendation: The U.B.C. should address the protection of steel structural elements specifically in Appendix Chapter 23, Division IV.

Suggested Code Change: See suggested code change for 4.2.2.

FEMA-114	U.B.C.	Analysis
6.2 Flood Wall Considerations	None.	FEMA-114 discusses the use of flood walls in the protection of residential structures. the U.B.C. requires that such buildings are elevated above the base flood elevation and has no provisions for such retrofitting of existing residential structures.

Recommendation: The U.B.C. should develop some provisions for the retrofitting of existing buildings or at least refer to approved national standards.

Suggested Code Change: Section 2396. Add Subsection (h) as follows: (h) Existing Buildings. Existing buildings may be floodproofed using flood walls, wet floodproofing or other approved methods when approved by the building official.

armstrong\spec-pro\fema-doc.cda

Recommended Changes to NFPA Standards
NATIONAL ELECTRICAL CODE (NFPA 70)

FEMA-54	NFPA 70	Analysis
Service Mounting P. 92 P. 93	110-13	Secure mounting of utilities and mechanical equipment are addressed in FEMA-54. NFPA 70 requires electric equipment to be securely fastened to the surface on which it is mounted.

Recommendation: Revise FEMA-54 to clarify that electric equipment shall be securely fastened to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used. Underground electric supply conduits or cables should not be fastened to walls, or strucures intended to break-away under flood conditions.

Suggested Code revision:
NFPA 70 (110-13(a), 300-5(d)).
Add the following sentence: Buildings designed with breakaway walls shall have electric services secured to the sides of interior piles or within flood proof enclosures attached to interior poles.

Recommended Changes to Manufactured Housing Codes and Standards

1989 CABO OTFDC, Appendix C

NFIP	CABO App. C	Analysis
§60.3		CABO App. C does not contain any special provisions for the installation of manufactured homes in flood hazard areas.

Recommendation: CABO Appendix C should be revised to include a reference to the NFIP for manufactured home installation in flood hazard areas.

Suggested Code Change [or addition]: Add to Appendix C Section C-101 - Scope, last §, last sentence: Refer to National Flood Insurance Program for installations in flood hazard areas.

FEMA 114	CABO App. C	Analysis
3.5 Extended foundation walls	C-503.2	Appendix C itself does not cover foundation walls; however Section C-503.2 refers to other provisions in CABO by stating that retaining walls used as permanent perimeter enclosure must conform to the code provisions for foundation walls. Section R-304, Foundation Walls, prescribes specific designs for masonry, concrete and stone foundation walls. [Reference Tables R-304.3a, 3b.] None of the prescribed designs in the CABO Tables are usable to resist hydrostatic, hydrodynamic, or impact loads specified in FEMA 114. Hydraulic venting of the foundations, as provided in FEMA 114, is not specified in CABO. R-304.5 in CABO prescribes all wood foundation wall designs. The comparisons noted above are applicable.

Recommendation: Clarification is needed for the CABO tables to state that designs subject to flood loads require special consideration for such loads that have not been accommodated in the tabulated designs.

Suggested Code Change [or addition]: Add a sentence to the end of §R-304.4:

R-304.4 Design required: . . . accepted engineering practices. Note that designs subject to flood loads require special consideration. Flood loads have not been accommodated in the designs in Tables R-304.3a and R-304.3b.

FEMA 114		CABO App. C	Analysis
3.13	Technical design criteria – Anchorage of superstructure to foundation	C-605	CABO C-605 requires that "wood floor support systems shall be fixed to perimeter foundations in accordance with this code." CABO Figure R-303 specifies the anchorage of sill plates to concrete foundations using ½"ϕbolts, 6' o.c. maximum. CABO Table R-402.3a specifies joists secured to sills using 3-8d nails, toe nailed. No provision is made to resist hydrostatic lift-off of the floor.

Recommendation: Clarification is needed in CABO C-605 that additional anchorage may be needed to resist hydrostatic lift in flood-prone areas. Reference to FEMA 85 may suffice.

Suggested Code Change [or addition]: In §C-605, add a sentence that follows the second sentence in the second paragraph:

. . . resist the wind load stated in this code. Note that additional anchorage is needed to resist buoyancy due to flooding in those areas where applicable.

FEMA 114		CABO App. C	Analysis
3.14	Technical design criteria — Open foundations	C-602, C-603, C604, C-605	CABO C-602 (Pier Construction) specifically excludes lateral wind and earthquake loads from consideration in the application of the piers specified in this code. Note that the typical manufactured housing foundation system uses diagonal ties that are secured to ground anchors for lateral load resistance. CABO C-603 (Height of Piers) specifies construction details for three height ranges of pier application. Each of these designs is to be used with the anchors and ties specified in Sections C-604 and C-605 respectively. The reliability of ground anchors in flooded soils has not been demonstrated. It would be prudent at this time to specifically disallow their use in the flood plains.

Recommendation: Clarification is needed in CABO to caution that the ground anchor system specified is generally not rated for flooding or for high open foundations.

Suggested Code Change [or addition]: At the end of §C-604.1,add: The use of ground anchors is permitted in the floodplain only when substantiating data are provided that satisfy the authority having jurisdiction.

FEMA 85		CABO App. C	Analysis
Pg. 22	Piers	C-602	a) FEMA 85 requires the bottom of the pier footing to extend a minimum of 30 in. below grade. CABO only requires the footings to extend a minimum of 12 in. below finished grade. Both require the footing to extend below the frost line. b) FEMA 85 requires built-up piers to be laid with type M or S mortar. In addition to types M or S, CABO permits Type N mortar. No incompatibilities.

Recommendations: Since the 30 inch requirement would be excessive for piers located in areas where scouring is not a problem, two separate requirements in FEMA 85 and CABO for minimum pier depths should be made depending on the flow conditions likely to be encountered.

Suggested Code Change [or addition]: In §C-602, add to the last sentence . . . wind, flood pressure, scouring, or earthquake forces.

FEMA 85		CABO App. C	Analysis
Pg. 53	Posts and Piles		CABO generally covers time-tested construction methods. It does not cover seldom-used systems such as posts or pile construction methods. The requirements are compatible as long as it is understood that CABO Appendix C is not applicable to flood loads.

Recommendation: Change CABO Appendix C to clarify that it does not consider flood loads.

Suggested Code Change [or addition]: In §C-602, add to the last sentence . . . wind, flood pressure, scouring, or earthquake forces.

FEMA 114	HUD 4930.3	Analysis
3.5 Extended foundation walls	102-2.C Standards	HUD 4930.3 references FEMA 85 for manufactured homes on elevated foundations.
	201-2.B	HUD 4930.3 provides that homes built on elevated foundations must comply with requirements of the NFIP and to refer to FEMA 85 for Manufactured Home Installation in Flood-Hazard Areas.
	402	Chapter 4 in HUD 4930.3 makes no provision for the application of hydrostatic, hydrodynamic, or impact loads.

Recommendation: Since provision is made for coastal wind forces in Section 402.3 of HUD 4930.3, it is advisable to include in HUD 4930.3 either complete design provisions for flooding, or a notice that additional lateral, hydrostatic, hydrodynamic, and impact loads need to be included for foundation walls subjected to flooding.

Suggested Change [or addition]: (a) Change §201-2.B.2 to read: "Homes built on elevated foundations in communities that are part of the National Flood Insurance Program (NFIP) must comply with the NFIP."

(b) Change §402-3.B to add item #3: If the site is in a floodplain, hydrostatic, hydrodynamic, and impact loads must be considered. Refer to FEMA 85 for guidance.

FEMA 114		HUD 4930.3	Analysis
3.12	Technical design criteria — Extended wall foundations	App. H12	The Wind Speed Map, H-12, in HUD 4930.3 corresponds with the 50-year mean recurrence map in Figure C-5b of FEMA 114.
		App. H1	The Flood Map, H-1, in HUD 4930.3 does not provide any provisions for hydrostatic, hydrodynamic, static loads.

Recommendation: On the flood map in HUD 4930.3, it is necessary to include a notice to design for lateral, hydrostatic, hydrodynamic, and impact loads for foundation walls subjected to flooding. Reference to FEMA 85 will suffice.

Suggested Change [or addition]: Revise the Flood Map on Page H-1 to include the following:

Note: 1. Consult with local Building or Planning Office to determine whether home is in the floodplain.
2. See FEMA 85 for recommended hydrostatic, hydrodynamic, and impact loads to be applied to foundation walls subject to flood.

FEMA 114		HUD 4930.3	Analysis
3.13	Technical design criteria — Anchorage of superstructure to foundation	App. B	The designs in HUD 4930.3 are apparently to resist wind and gravity loads only. No provision has been made for buoyancy. The loads given for vertical uplift in Table B-2 of HUD 4930.3 would be ample for approximately 1.7' water depth above the top of the foundation.

Recommendation: Include a notice in Appendix B, Table B1 of HUD 4930.3 that additional anchorage may be required in areas subject to flooding in order to resist hydrostatic, hydrodynamic, and impact loads.

Suggested Change [or addition]: Provide a note at the end of the first paragraph in Appendix B:

Note: Additional anchorage may be required to resist hydrostatic, hydrodynamic, and impact loads in areas subject to flooding. Refer to FEMA 85.

FEMA 114	HUD 4930.3	Analysis
3.14 Technical design criteria – Open foundations	203	HUD 4930.2 identifies "unstable clays" as a possible cause for foundation instability, while the FEMA 114 favors clay soils for their resistance to scouring. These provisions are incompatible.

Recommendation: Further research/study is recommended to reconcile the limits for foundations in clay soil. This study should be undertaken in a collaborative effort by HUD, FEMA, and the manufactured housing industry.

FEMA 114	HUD 4930.3	Analysis
6.2 Considerations	301-1	The provision in HUD 4930.3, "provide the best available routing of run-off water to assure that buildings or other important facilities will not be endangered by the path of a major emergency flood run-off which would occur if the site storm drainage is exceeded," does not provide notice that this might require the use of flood walls. FEMA 114 discusses the fact that flood wall design is dependent upon the type of flooding expected.

Recommendation: In HUD 4930.3, Section 301-1, include a statement that adequate flood walls provide one way to accomplish the rerouting of run-off water.

Suggested Change (or addition): Add a sentence to the end of §301-1:

One way to accomplish rerouting of run-off water in retrofitting is to use flood walls. Refer to FEMA 114 for examples.

Note: Flood walls are not acceptable for new installations.

FEMA 114	HUD 4930.3	Analysis
9.4 Permanent protective measures	Chapter 7	There is no provision in HUD 4930.3 for flood protection of utilities. The overall emphasis of this publication is on structural aspects. The scope of Chapter 7 (Final Check) is limited to foundation design.

Recommendation: In HUD 4930.3, refer to FEMA 85 for home installations in flood-prone areas in order to provide protection of utilities.

Suggested Change (or addition): Add a Section 7004:

700-4 Flood Protection of Utilities

For homes subject to flooding, verify that provisions have been made in the design to protect utilities. Refer to FEMA 85 for methods.

FEMA 85	HUD 4930.3	Analysis
pg. 48 Piers	App. A	FEMA 85 prescribes designs for piers, and cautions that, due to the likelihood of scouring, pier systems should not be used in areas where flooding velocity is anticipated. Appendix A of HUD 4930.3 recommends Foundation Type C2 [reinforced masonry or concrete piers] for high wind and indicates that engineering design is not required. While the Flood-Prone Sites exclusions provided in Section 201-2 might be sufficient for some designers, it seems prudent that it be repeated in the Appendices.

Recommendation: The design appendices in HUD 4930.3 should repeat the references to the FEMA documents and caution that the designs presented have not taken flood conditions into account.

Suggested Change (or addition): Add a sentence to Paragraph B, Page A-1: Note that none of the charted designs takes flood loads into account. Refer to FEMA 85 for design loads and procedures.

Manufactured Housing Institute
Model Installation Manual [MHI-MIM]

FEMA 85	MHI-MIM	Analysis
pg. 17 Wind hazards	4.4.2 5.4 5.4.1 5.4.2	FEMA 85 and MHI-MIM are not incompatible; FEMA 85 reiterates the same lateral and uplift design wind pressures as the MHCSS. The requirements of MHI-MIM are based on the design wind loads in the MHCSS. Please note, however, that Section 5.4 in MHI-MIM states that, "... the installer should secure the home against the wind *unless the local jurisdiction permits otherwise*." (emphasis added) It appears that FEMA 85 requires the anchoring of homes against wind loads under all circumstances.

Recommendation: It is not intended that a participant in the NFIP (i.e., local jurisdiction) would not require that a home not be anchored against wind loads. However, the compatibility of the documents would be enhanced by a revision to MHI Section 5.4 to state that anchorage of the unit against wind forces is always required.

Suggested Change [or addition]: Change Paragraph 5.4 Anchoring Instructions. After blocking and leveling, the installer should secure the home to resist the wind forces required in this manual or higher wind forces if required by the authority having jurisdiction.

MCRB	MHI-MIM	Analysis
	4.5	The MHI-MIM provides a list of important reference documents. The Manual for the Construction of Residential Basements in Non-Coastal Flood Environs is not included in the list.

Recommendation: Change the "List of Important Documents" in MHI-MIM to include Manual for the Construction of Residential Basements in Non-Coastal Flood Environs.

Suggested Code Change [or addition]: Add to the "List of Important Documents" in MHI-MIM the following: Manual for the Construction of Residential Basements in Non-Coastal Flood Environs.

ANSI A225.1-1987
Manufactured Home Installations [A225.1]

FEMA 85	A225.1	Analysis
pg. 33 Design of elevated foundations	Appendix B B-4.1	FEMA 85 and A225.1 use the roof live loads and wind loads from the HUD MHCSS. A225.1 states that areas where recurrent winds up to 90 miles per hour (25 psf) are experienced should use similarly designed manufactured homes.

Recommendation: ANSI A225.1 should define the specific areas where wind loads of higher magnitude than the 25 psf limit are needed.

Suggested Standard Change [or addition]: Change Paragraph B-4.1 The Wind Zone Map, last sentence as follows: Consult the authority having jurisdiction. Note that an enlarged supplementary map of the Gulf and Atlantic Coastal areas has been supplied in order to more reliably determine the high wind zones. Provide such a map.

FEMA 85	A225.1	Analysis
pp 47-48 Vertical support members	Appendix B	FEMA 85 provides design charts for dead load, live load, snow load, and wind load calculations. The charts use snow and wind loads from the HUD MHCSS. [Homes manufactured since 1976 under the HUD Standards are themselves certified to those loads] A225.1 uses the same live, snow, and wind loads as FEMA 85.

Recommendation: Revise ANSI A225.1, Appendix B, to incorporate ASCE-7 snow and wind loads.

Suggested Standard Change [or addition]: Add a Paragraph:

B-4.3 Flood Loads:

Refer to FEMA 85 for flood loading. The loads in these Tables do not include loads attributable to flooding.

FEMA 85	A225.1	Analysis
pg. 48 Piers	Appendix C	FEMA 85 prescribes designs for piers, and cautions that, due to the likelihood of scouring, pier systems should not be used in areas where flooding velocity is anticipated. Appendix C of A225.1 provides designs for pier foundations and issues no cautions concerning scouring. (Note that overall A225.1 is not for homes sited in flood- prone areas.)

Recommendation: Appendix C of A225.1 should reference the FEMA documents and caution that the designs presented have not taken flood conditions into account.

Suggested Standard Change [or addition]: Add a paragraph after the introductory paragraph to Appendix C, second column:

Flood Designs:

Refer to FEMA 85 for flood designs and design methods. These designs do not include loads attributable to flooding.

Manufactured Home Construction and Safety Standards (MHCSS)

FEMA 114	MHCSS	Analysis
3.12 Technical design criteria -- Extended wall foundations	§3280.305(c)	Section 3.12 of FEMA 114 refers to Appendix C for design loads, which in turn refers to the three model building codes for determination of wind loading characteristics. The wind design data presented in Appendix C is not necessarily in agreement with the wind design criteria in §3280.305(c) of the MHCSS. While §3280.305(c)(2)(ii) states that HUD may establish more stringent requirements in areas with 125 mph and greater recorded wind velocity, HUD has not been known to establish more stringent requirements than those specified in §3280.305(c)[25 psf lateral, 15 psf uplift].

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

FEMA 114	MHCSS	Analysis
3.13 Technical design criteria – Anchorage of superstructure to foundation	§3280.305(c)	Section 3.13 of FEMA 114 covers the importance of the floor diaphragm in maintaining the stability of the foundation walls and cautions against using connections that pull out if the underside of the floor is subjected to upward hydrostatic forces. Hydrostatic forces are not covered in the HUD MHCSS. However, Zone II (hurricane) homes when designed in accordance with §3280.305(c)are connected to the steel frame - chassis so as to sustain 15 psf uplift. (Caution, this is not sufficient for hydrostatic pressures in excess of 3" water column.)

Recommendation: FEMA research on the effects of hydrostatic pressure on manufactured homes has resulted in the requirement to elevate above BFE. If HUD and the manufactured housing industry were to embark on a program to set construction standards for homes sited in flood prone areas, a method of certification similar to the wind zone map and label used in the present MHCSS needs to be devised to provide notice on the homes that identifies the flood intensity for which the home is constructed.

FEMA 114	MHCSS	Analysis
C.4 Wind loads	§3280.305(c)(1) and (2)	MHCSS specifies that the wind design forces for homes designated for Zone I, non-hurricane, shall be 15 psf lateral and 9 psf uplift, and the wind design forces for Zone II, hurricane, shall be 25 psf lateral and 15 psf uplift. In FEMA 114, wind zones are delineated in wind velocities (mph) according to the ANSI A58.1 map for 50-year recurrence. When applying the formulas from ANSI A58.1, the resulting wind pressures in high wind zones may exceed the MHCSS minimum pressures. §3280.305(c)(2)(ii) states that HUD may establish more stringent requirements than those specified in §3280.305(c)for areas with 125 mph and greater wind velocities.

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

Recommended Changes to the One and Two Family Dwelling Code

NFIP	OTFDC	Analysis
60.3(c)(5) Flood Openings	R-311	NFIP requires fully enclosed areas below the lowest floor, other than basements, to be provided with flood openings to equalize hydrostatic flood forces. OTFDC does not address floodplain management; however, it does require openings for crawl space ventilation.

Recommendation: OTFDC should address openings for floodwater and equalize hydrostatic forces.

Suggested Code Change [or addition]:

R-311.5 Floodplain: All elevated buildings that include fully enclosed areas formed by foundation and other exterior walls below the base flood elevation shall be designed to allow for the entry and exit of floodwaters to automatically equalize hydrostatic flood forces on exterior walls. Designs for meeting this requirement must either be certified by a professional engineer or meet the following minimum criteria: a minimum of two openings having a total net area of no less than 1 square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than 1 ft above grade. Openings may be equipped with screens, louvers, valves or other coverings or devices provided they permit the automatic flow of floodwaters in both directions.

FEMA 55	OTFDC	Analysis
4.1.2 Salt Air Moisture and Wind-Driven Rain (Pages 4-7, 4-8)	R-309 R-404.14.1	FEMA provides general discussion of the hazards of salt air, moisture, and wind-driven rain on wood, nails, and connectors. OTFDC requires wood subject to decay damage to be naturally durable or pressure treated but does not address nails or connectors. OTFDC does address corrosion protection of joint reinforcement, anchor ties, and wire fabric for use in masonry wall construction.

Recommendation: OTFDC should address corrosion protection.

FEMA 55	OTFDC	Analysis
4.2.3.2 Steel (Page 4-11)	R-403 R-605 R-705.1	FEMA 55 addresses the problem of corrosion of unprotected steel shapes and anchoring devices (nails, bolts, etc.) and the need for regular inspection, maintenance, and replacement of corroded metal parts. OTFDC requires the steel to comply with the appropriate standards. OTFDC does not address corrosion in coastal environment.

Recommendation: OTFDC should address corrosion protection.

Suggested Code Change [or addition]:

R-402.3 Construction: Exterior walls of wood-frame construction shall be in accordance with Figure Nos. R-402.3a and R-402.3b. Components of exterior walls shall be fastened in accordance with Table No. R-402.3a. Walls of wood frame construction shall be designed and constructed in accordance with the NFoPA "National Design Specification for Wood Construction," listed in Section S-26.402.

Exterior walls shall be effectively braced with let-in bracing, plywood in accordance with Table No. R-402.3b, particleboard in accordance with Table No. R-402.3c or other approved materials.

Exterior walls subject to wind pressures greater than 30 pounds per square foot, as established in Table No. R-201.2, shall be designed in accordance with accepted engineering practice.

Metal plates, connectors, screws, bolts, and nails exposed directly to the weather or subject to salt corrosion in coastal areas shall be stainless steel or hot-dipped galvanized, after the fastener or connector is fabricated.

Suggested Code Change [or addition]:

SECTION R-605 – METAL

Steel and aluminum structural elements shall be constructed of materials and designed in accordance with the AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" and AASAS30, respectively, listed in Section S-26.605. Steel elements may be hot-rolled or cold-formed structural steel. Members shall be straight and free of any defects which would affect their performance.

Structural steel exposed directly to the weather or subject to salt corrosion in coastal areas shall be hot-dipped galvanized after fabrication.

Suggested Code Change [or addition]:

R-705.1 Steel elements: Steel structural elements in roof-ceiling construction may be either hot-rolled structural steel shapes or members cold formed to shape from steel strip or plate or a fabricated combination thereof. Members shall be straight and free of any defects which would significantly affect their structural performance. Steel structural members in roof-ceiling construction shall be designed in accordance with the AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" listed in Section S-26.705.

Structural steel exposed directly to the weather or subject to salt corrosion in coastal areas shall be hot-dipped galvanized after fabrication.

APPENDIX 1

PROJECT PARTICIPANTS

Project Committee

Chairman: G. Day Ding, California Polytechnic Institute
Vice-Chairman: Earl L. Flanagan, Housing & Urban Designs
Secretary: Brad Douglas, National Forest Products Association

Paul Armstrong, International Conference of Building Officials
Earl R. Bell, USDA Farmers Home Administration
Francis W. Biehl, Biehl Engineering, Inc.
Peter L. Bolzer, South Dakota Fire Marshal's Office
Richard Dixon, Florida Dept of Community Affairs
William W. Dunlop, Code Consultant
W. Robert Frost, State Fire Marshal's Office
Hugh Jay Gershon, Hugh Jay Gershon, Architect, AIA
Henry L. Green, State of Michigan
Martin Jay Hanna, III, P.E., Hanna Fire Engineering Corp.
Paul K. Heilstedt, P.E., Building Officials & Code Administrators Intl
Dorsey D. Jacobs, West Virginia University
Jerry W. Jones, Louisiana State Fire Marshall
John H. Jones, CBO, CPCA, Code Consultant
Timothy A. Keptner, Pennsylvania Dept. of Community Affairs
Alvin Kleinbeck, State of Minnesota
Richard P. Kuchnicki, Council of American Building Officials
W. Max Lucas, University of Kansas
Lance L. Luke, Lance L. Luke & Associates, Inc.
Francis A. Mancini, National Committee on Property Insurance
Joseph J. Messersmith, Jr., Portland Cement Association
John J. Mulady, United Services Automobile Assoc.
James K. Murphy, P.E., Dewberry & Davis
Spencer M. Rogers, Jr., Sea Grant Marine Advisory Service
Jon S. Traw, International Conference of Building Officials
Frank Walter, P.E., Manufactured Housing Institute
Leonard G. Wehrman, National Foundation of Manufactured Home Owners
Joel P. Zingeser, AIA, Building Technology, Inc.

Subcontractors

Paul Armstrong, International Conference of Building Officials
John Battles, Southern Building Code Congress International
Gregory Cahanin, National Fire Protection Association
Tom Frost, Building Officials and Code Administrators International, Inc.
Billy Manning, Southern Building Code Congress International
Kate McQueen, National Conference of States on Building Codes & Standards

NIBS Project Staff

Philip Schneider, AIA, Director of Technical Programs

APPENDIX 2

ACRONYMS

AA	Aluminum Association
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
AWPA	American Wood-Preservers' Association
BCMC	Board for the Coordination of the Model Codes
BFE	Base flood elevation
BOCA	Building Officials and Code Administrators International
CABO	Council of American Building Officials
CFR	Code of Federal Regulations
FEMA	Federal Emergency Management Agency
HUD	Department of Housing and Urban Development
HVAC	Heating, ventilating and air-conditioning
ICBO	International Conference of Building Officials
LP	Liquified petroleum
LPG	Liquified petroleum gas(es)
MCRB	Manual for the Construction of Residential Basements in Non-Coastal Environs
MHCSS	Manufactured Housing Construction Safety Standards

MHI	Manufactured Housing Institute
MHIM	Manufactured Housing Installation Manual
NCSBCS	National Conference of States on Building Codes and Standards
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NFoPA	National Forest Products Association
OTFDC	One and Two Family Dwelling Code
SBC	Standard Building Code
SBCCI	Southern Building Code Congress International
SFM	Standard for Floodplain Management
SGC	Standard Gas Code
SMACNA	Sheet Metal & Air Conditioning Contractors National Association
SMC	Standard Mechanical Code
SPC	Standard Plumbing Code
UBC	Uniform Building Code

APPENDIX 3

SUMMARIES OF NFIP FLOOD RESISTANT DESIGN STANDARDS AND TECHNICAL GUIDANCE DOCUMENTS

National Flood Insurance Program Regulations for Floodplain Management and Flood Hazard Identification (44 CFR 59.1, 60.3 & 60.6)

These three sections of the Federal regulations that govern the NFIP contain general flood resistant design standards (60.3), flood resistant design standards for basements (60.6), and associated definitions (59.1). These are the regulations that a community must adopt and enforce in order to participate in the NFIP.

Coastal Construction Manual (FEMA-55)

This document is applicable to new residential structures, principally detached single-family, attached single family (townhouses), low-rise (three story or less) multi family houses and similar sized non-residential structures in coastal areas of the United States. The manual is based on evaluation of existing beach houses, current construction practices along U.S. coastlines and various building codes applicable to construction. The document primarily addresses design of wood-frame structures for flood and wind resistance, and is meant to serve as a parallel to model building codes. The information presented is based upon values of forces and properties of materials taken from standard engineering references and conventional building codes. Generally, conservative approaches and values have been used to provide conformance with most applicable national building codes. A limited range of sizes and configurations for single-family residences has been assumed for purposes of establishing design criteria and tables. A sample building code is provided for local jurisdictions that wish to develop a coastal construction code to supplement their governing building code.

Elevated Residential Structures (FEMA-54)

This manual is limited to the special design issues confronted in elevated construction. Readers are assumed to have knowledge of conventional residential construction practice. The techniques described for the design and construction of elevated residential structures is based on accepted building practices. Generally, a conservative approach has been taken to ensure compliance with building codes most widely used in the United States. This document also contains a set of performance criteria applicable to all structural materials and construction methods used in flood hazard areas. Traditional or conventional solutions, as well as innovative techniques, are acceptable so long as the performance requirements and criteria are satisfied.

Retrofitting Flood-Prone Residential Structures (FEMA-114)

This manual describes the application of permanent retrofitting measures particularly elevation, floodwalls and closures that can be implemented in a residential structure to reduce flood damage. Elevation techniques described in the manual are not addressed in the model codes and standards, however, the altered structure is treated by the codes as a new structure.

Floodproofing Non-Residential Structures (FEMA-102)

This document illustrates a broad range of floodproofing techniques that can be used to reduce flood damage to existing or proposed non-residential (industrial, commercial and institutional) structures in riverine flooding and flooding in no-wave velocity coastal areas. These structures range from wood-frame to multi-story concrete and steel structures. Much of the information regarding design criteria, the properties of materials, the values of flood water design forces, and other considerations have been adopted from standard engineering references, building codes, and other documents. This manual is intended to serve as a general technical guide on the selection of alternative floodproofing techniques. Actual design and construction should involve the services of a registered professional engineer, architect or experienced contractor. An appendix provides floodproofing performance criteria for the design and evaluation of floodproofing measures.

Manufactured Home Installation in Flood Hazard Areas (FEMA-85)

This document primarily addresses techniques for elevating manufactured homes above anticipated flood levels. Chapter 1 states that siting and installation requirements for manufactured homes are generally a state or local regulatory responsibility and are not within the scope of the Manufactured Housing Construction Safety Standards (MHCSS). However, the MHCSS require the installation procedures be incorporated in the owner's manual supplied with each new manufactured home. Installation procedures in both the owner's manual and ANSI A225.1-82 are not considered adequate in cases where flood forces are anticipated. (This statement needs to be tested for ANSI A225.1-87.)

Alluvial Fans: Hazards and Management (FEMA-165)

This document contains very general guidelines for building in flood-prone areas on alluvial fans which are found in arid western regions. With the exception of provisions for window and door locations, these guidelines are covered in greater detail in the other FEMA publications.

Design Guidelines for Flood Damage Reduction (FEMA-15)

This document describes an overview of the flood regulatory program and site considerations. As it does not address design and construction, it will not utilized as a source of technical guidelines for this project.

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs

This manual provides practical guidance and specific design options to assist in meeting the requirements of the NFIP for floodproofed residential basements. It is intended also as a tool for those called upon to certify that floodproofed residential basements meet the standards of the program. The manual presents two basic systems for waterproofing residential basements. One system envisions the

use of conventional wall and slab surface treatments along with a total drain, sump, and pump operation to keep water away from basement walls. The other system envisions the use of a more water-tight wall and slab surface treatment without a sump or pump. A "builder's guide" is also included for use by contractors.

Technical Standards Bulletin: Wet Floodproofing, No. 85-1

This document provides basic information concerning the application of wet floodproofing (intentional internal flooding) techniques to new and existing non-residential construction. Sections of the bulletin also address operational procedures to reduce vulnerability to damage. Guidance presented is the result of a review of state of the art and actual field experience with such techniques.

Technical Standards Bulletin: Foundation Wall Openings, No. 85-2

This document addresses the structural requirements of a building's foundation system that may be subject to flood forces by placing a number of permanent openings in the foundation wall. The guidelines are applicable to solid load bearing walls which elevate the building or any type of enclosure constructed around the foundation.

Technical Standards Bulletin: Breakaway Walls, No. 85-3

This document addresses the design of breakaway walls defined as walls which are not part of the structural support of the building and are intended to collapse under specific lateral loads with causing damage to the building. Breakaway wall designs are based on the premise of connection failures. Breakaway walls may be used to enclose spaces below the flood elevation meant for parking of vehicles, building access and storage.

Technical Standards Bulletin: Hurricane Damage Patterns: A Focus on Pile Foundations, No. 86-1

This document represents an introductory approach to pile design and repeats information more thoroughly described in other publications. Thus, it will not be utilized for comparisons with codes and standards documents.

Technical Standards Bulletin: Wind Design Standards and the NFIP, No. 88-1

This document describes the application of ANSI A58.1 which describes wind loads and speeds. The document states that all three model building codes have adopted some version of this standard.

Technical Standards Bulletin: Flood Resistant Materials, No. 88-2

This document provides data and guidance on what constitutes materials resistant to flood damage and how they should be used to improve a structure's ability to withstand flooding. The most common use of this requirement is with regard to construction below a structure's lowest habitable floor which is required to be elevated above the base flood elevation, and with applications of wet floodproofing. This requirement means that all construction below the lowest floor, which can be used for parking, building access and limited storage must consist of flood resistant materials in order to withstand

inundation by flood waters.

Technical Standards Bulletin: Free of Obstruction Requirement in Coastal High Hazard Areas, No. 88-3

This document provides guidance on the NFIP requirement to keep the space below the lowest floor free of obstruction.

Technical Standards Bulletin: Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4

This document provides an explanation of elevators, their related equipment, and practical methods of protecting them from flood damage.

Technical Standards Bulletin: NFIP Pile or Column Requirement in Coastal High Hazard Areas, No. 90-1

This document represents an introductory approach to pile design and repeats information more thoroughly described in other publications. Thus, it will not be utilized in for comparisons with codes and standards documents.

Technical Standards Bulletin: NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2

This document provides technical guidance on the design of below grade parking garages in flood hazard areas. A below grade parking garage is an enclosed area below a building used for parking. The floor of the enclosed area is subgrade or below ground on all sides.

Technical Standards Bulletin: Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3

This document details the design and construction considerations necessary to comply with the floodproofing certification requirements of the NFIP for non-residential structures. It also describes operation and maintenance procedures for floodproofing.

Technical Standards Bulletin: Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4

This document provides the application of floodplain management regulations affecting the installation of manufactured homes and general technical guidance in constructing elevated manufactured home foundations.

APPENDIX 4

SUMMARIES OF MODEL CODES AND STANDARDS

BOCA National Building Code (1990)

This code controls all matters concerning the construction, alteration, addition, repair, removal, demolition, use, location, occupancy and maintenance of all buildings and structures. For this study the code addresses administration and enforcement (Chapter 1), height and area (Chapter 5), anchorage (Chapter 6), insulating materials (Chapter 9), structural considerations (Chapter 11), foundations (Chapter 12), construction materials (Chapters 14, 15, 17, 18 & 19), exterior walls (Chapter 21), glass (Chapter 22), and roofs (Chapter 23). Fire safety is covered in primarily in Chapters 5 and 9. Wind and seismic requirements are covered in Chapter 11.

BOCA National Fire Prevention Code (1990)

This code applies to the hazards of fire and explosion arising from the storage, handling or use of substances, materials or devices and from conditions hazardous to life, property, or public welfare in the use or occupancy of buildings structures and sheds. For this study the code addresses floodproofing of underground storage tanks (Chapter 28). Seismic considerations are not explicitly addressed in this chapter.

BOCA National Mechanical Code (1990)

This code applies to the design, installation, maintenance, alteration and inspection of mechanical systems, including, heating, ventilating, cooling, and steam and hot water heating systems, water heaters, process piping, and other systems. For this study the code addresses plenums and ducts (Chapters 3 and 5), hazardous and outdoor locations of mechanical equipment (Chapter 4), and floodproofing of water, gas and other fluid piping (Chapters 7, 8 & 9). Fire, wind and seismic considerations are not explicitly addressed in these chapters.

BOCA National Plumbing Code (1990)

This code applies to the design and installation of plumbing systems, including sanitary and storm drainage, sanitary facilities, water supplies, and storm water and sewage disposal in buildings. For this study this code addresses the floodproofing provisions for piping (Chapter 3), connections (Chapter 5), drainage piping (Chapter 6), manholes (Chapter 11), and water service (Chapter 15 and 16). Fire, wind and seismic considerations are not explicitly addressed in these chapters.

BOCA National Property Maintenance Code (1990)

This code applies to existing structures, residential and nonresidential, and on all existing premises by establishing minimum requirements and standards for premises, structures, buildings, equipment, and facilities for light, ventilation, space, heating, sanitation, protection from the elements, life safety, safety from fire and other hazards and for safe and sanitary maintenance. For this study the code addresses the exterior structure (Article 3) and mechanical equipment (Article 6). Fire, wind and seismic considerations are not explicitly addressed in these chapters.

Standard Building Code (1991)

This code applies to the construction, alteration, repair, equipment, use, occupancy, location, maintenance, removal and demolition, of every building or structure or any appurtenances connected or attached to such buildings or structures. For this study the code addresses parking (Chapter 4), standby power and accessibility (Chapter 5 and Appendix I), unusable space and open parking structures (Chapter 6), chutes and tanks (Chapter 7), chimneys, plumbing and plenums (Chapter 8), egress and exits (Chapter 11), structural requirements (Chapter 12), foundations (Chapter 13), masonry construction (Chapter 14), wood construction (Chapter 17), one and two family dwellings (Appendix C), and manufactured homes (Appendix H). Fire safety is covered in primarily in Chapters 6, 7, 8 and 11. Wind, snow and seismic requirements are covered in Chapter 12.

Standard for Floodplain Management (1989)

This code provides criteria to meet the minimum, floodplain construction requirements as required by the National Flood Insurance Program. Fire, wind, snow and seismic considerations are not explicitly addressed in this document.

Standard Mechanical Code (1991)

This code provides minimum requirements for mechanical installations, including alteration, repair, replacements, equipment, appliances, fixtures, fittings and appurtenances. For this study the code addresses under floor installations (Chapter 3), condenser and compressor units (Chapter 4), duct systems (Chapter 5), and piping (Chapter 6). Fire, wind, snow and seismic considerations are not explicitly addressed in these chapters.

Standard Gas Code (1991)

This code provides minimum requirements for installation of gas piping and appliances. For this study the code addresses meter location and piping (Chapter 3), air for combustion and ventilation (Chapter 4), furnaces (Chapter 5), and butane and propane piping (Chapter 9). Although fire safety requirements are not explicitly stated, one of the purposes of the gas code is to prevent fires, particularly explosions. Wind, snow and seismic considerations are not explicitly addressed in these chapters.

Standard Plumbing Code (1991)

This code provides minimum requirements for plumbing installations, including alteration, repair, replacements, equipment, appliances, fixtures, fittings and appurtenances. For this study the code addresses protection of pipes and sewage systems (Chapter 4 and Appendix E), traps and cleanouts (Chapter 7), hangers and supports (Chapter 10), water supply (Chapter 12), drainage systems (Chapter 13), and storm drains (Chapter 15). Fire, wind, snow and seismic considerations are not explicitly addressed in these chapters.

Uniform Building Code (1991)

This code regulates and controls the design, construction, installation, quality of materials, use and occupancy, location, and maintenance of all buildings and structures. For this study, the code addresses definitions (Chapter 4), general requirements for all occupancies (Chapter 5), general design requirements of construction materials (Chapter 23), specific requirements for materials (Chapters 24 through 28), foundations (Chapter 29), accessibility (Chapter 31), exits (Chapter 33), wall and ceiling coverings (Chapter 47), and excavations and grading (Chapter 70). Fire safety is primarily addressed in Chapters 5, 31 and 33, while wind and seismic requirements are addressed in Chapter 23 and its appendices.

Uniform Mechanical Code (1991)

This code regulates and controls the design, construction, installation, quality of materials, location, operation and maintenance or use of heating, ventilating , cooling, refrigeration systems, incinerators and other miscellaneous heat producing appliances. For this study, the code addresses heating, ventilating and cooling equipment in general (Chapter 5), and refrigeration equipment (Chapter 15). Fire, wind and seismic considerations are not explicitly addressed in these chapters.

Uniform Plumbing Code (1991)

This code applies to the erection, installation, alteration, repair, relocation, replacement, addition to, and use of maintenance of plumbing systems. For this study the code addresses drainage systems described in Chapter 4. Fire, wind and seismic considerations are not explicitly addressed in this chapter.

NFPA 101 - 1991 Life Safety Code

This code establishes the minimum requirements that will provide a reasonable degree of safety from fires in buildings. For this study the code addresses means of egress (Chapter 5), construction and compartmentalization and special hazards (Chapter 6), elevators and chutes (Chapter 7), special structures and high-rise buildings (Chapter 30), and operation and maintenance (Chapter 31). Applicable code provisions for each new occupancy listed in the document (Chapters 8 through 29) are also part of the study. Wind and seismic considerations are not explicitly addressed in these chapters.

NFPA 70 - 1990 National Electrical Code

This code addresses the practical safeguarding of persons and property from hazards arising from the use of electricity. The code covers installations of electric conductors and equipment within or on buildings and manufactured homes. For this study the code addresses electrical service (Chapter 2), wiring (Chapter 3), lighting, motors, and transformers (Chapter 4), and emergency systems (Chapter 7). Fire, wind and seismic standards are not explicitly referenced, however, one of the purposes of the electrical code is the prevention of electrical fires.

NFPA 54 - 1988 National Fuel Gas Code

For this study, this code offers general criteria for the installation of gas piping (Part 3) and gas equipment (Part 6). Although fire safety requirements are not explicitly stated, one of the purposes of the gas code is to prevent fires, particularly explosions. No specific wind or seismic standards are addressed.

NFPA 58 - 1989 Standard for the Storage and Handling of Liquified Petroleum Gases

This standard applies to liquified petroleum gas(es) also known as "LP-gas" and "LPG." The gases are composed predominately of propane, propylene, butane and butylene by themselves or as mixtures. For this study the standard applies to the design and construction (Chapter 2), installation (Chapter 3) and operation (Chapters 2 and 3) of all LP-gas systems excluding natural gas processing plants, frozen ground containers, utility gas plants, chemical plants, and LP-gas used with oxygen of covered by other standards. Chapter 7 addresses buildings or structures housing LP-gas distribution facilities. Fire safety requirements are listed for certain kinds of operations and for the structures described in Chapter 7. No specific wind or seismic standards are addressed.

ANSI A225.1-1987 Manufactured Home Installations

This standard covers the installation of manufactured homes on site and references fire safety requirements for the installation of manufactured homes. For this study, all chapters and selected appendices will be utilized. Chapter 1 describes the scope and intent of the document; Chapter 2 describes installation standards. Chapters 3 and 4 reference installation of plumbing systems and mechanical equipment, respectively. In Chapter 7, NFPA 501A is referenced for fire safety requirements, and in Chapter 6, NFPA 70 is referenced for electrical systems. A wind zone map in Appendix B provides horizontal and uplift loads to be used in determining anchoring requirements. No seismic standards are referenced.

Manufactured Home Construction and Safety Standards, Part 3280

This standard covers all equipment and installations in the design, construction, fire safety, plumbing, heat producing and electrical systems of manufactured homes. For this study sections have been referenced on materials (304), structural design (305), windows (403), egress windows (404), heating, cooling and fuel burning systems (Part H), and electrical systems (Part I). Interpretative bulletins are also part of the study. Fire safety requirements addressing egress are found in section 404. Sections 305 and 306 provide standards for anchoring and windstorm protection. Subsection 305 provides the same wind zone map found in ANSI A225.1-1987. No seismic standards are referenced.

Permanent Foundations Guide for Manufactured Housing, 4930.3

This handbook provides guidelines on the design of foundations for manufactured homes. For this study sections have been referenced on flood-prone sites (Chapter 2), fill (Chapter 3), design loads (Chapter 4), and foundation design (Chapters 5 and 6). Appendices describes foundation design in more detail. Chapter 4 addresses wind and seismic considerations.

Model Manufactured Home Installation Manual

This manual contains detailed installation instructions, including specifications and procedures for erection and hookup of a manufactured home. For this study chapters have been referenced on foundations (Chapter 4), anchoring (Chapter 5), comfort cooling systems (Chapter 7) connections for water supply, drainage systems, gas supply, and electrical systems (Chapter 8), and oil tank installations (Chapter 8). Chapters 4 and 5 also provides guidelines for windstorm and flood protection.

☆U.S. GOVERNMENT PRINTING OFFICE:1998-622-955/95449

NFPA 501A - 1987 Standard for Firesafety Criteria for Manufacture Home Installations, Sites and Communities

This standard covers firesafety requirements for the installation of manufactured homes and manufactured homesites including accessory buildings, structures and communities. For this study sections have been referenced on gas supply connections and oil tank installations (Chapter 2), and life and firesafety (Chapter 4). In Chapter 3, NFPA 70 is referenced for electrical systems. No seismic standards are referenced.

CABO One and Two Family Dwelling Code (1989) with 1990/1991 Amendments

The provisions of this code apply to the construction, prefabrication, alteration, repair, use, occupancy and maintenance of detached one- or two-family dwellings and one-family townhouses not more than three stories in height and their accessory structures. For this study the code addresses building planning (Chapter 2), foundations (Chapter 3), wall construction (Chapter 4), exterior wall coverings (Chapter 5), floor framing (Chapter 6), masonry chimneys (Chapter 9), mechanical systems (Chapters 11 through 17 & 19), and plumbing systems (Chapters 20, 22, 24 & 25). Seismic requirements are covered in Appendix A; wind requirements in Appendix B. Manufactured housing is addressed in Appendix C. Fire safety requirements are implicit in all chapters.